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Editorial.

The Physical Society Exhibition.

IN this issue we include a brief report upon the twenty-first Annual Exhibition of the Physical Society and the Optical Society, and it is an occasion to draw particular attention to the growing importance of this annual event.

The Exhibition started in the humblest fashion, but year by year has grown in interest and general scope until to-day it is one of the most important scientific exhibitions held in this country.

The Exhibition is not, we believe, run on the commercial lines associated with exhibitions in similar spheres; it was primarily introduced for the convenience of the membership, and during part of the time that the Exhibition is open it is still exclusively reserved to the members. Efforts are made by the organisers to encourage exhibitors who might ordinarily have no facilities for showing their inventions or work.

The Physical Society and the Optical Society are to be congratulated on having been instrumental in bringing together in one location such an enormous amount of interesting and important subject matter, but we venture to think that the Exhibition is now beginning to outgrow its organisation and that under the present arrangements it is impossible for the fullest benefits to be derived from the advantages which the Exhibition offers.

Our first criticism would be that the period of the Exhibition is by no means sufficient to enable all those who would wish to visit it to do so. It is open only for three days from 3 p.m. to 10 p.m., except for a morning session exclusively reserved to members. Of the three days, only on one, the last day, is the Exhibition open to the public generally, admission on other days being by ticket only.

Next we would say that, in our opinion, the housing of the exhibits is inadequate; we realise that questions of space must be difficult, but, nevertheless, there appears to be a very serious crowding together of many of the most important exhibits, especially those likely to attract the largest number of visitors. We believe much could be done to increase the usefulness of the Exhibition if these points received attention, and we only put forward these criticisms because we feel so strongly the importance of the Exhibition and the much greater advantages to be derived from it if more time and better opportunities could be provided for the study of the vast amount of material presented.

An Analysis of Distortion in Resistance Amplification.*

By E. B. Moullin, M.A., A.M.I.E.E.

(1) Introduction.

THE characteristic of a thermionic valve is not straight and no valve amplifier can reproduce the input voltage with perfect faithfulness. But characteristics have long straight portions and so the response is substantially faithful over a restricted range. So we may ask how straight must the characteristic be, and we should like a measure of distortion in terms of the curvature. In a complete broadcast receiver there are many things which make separate contributions to the resultant distortion, and it is desirable to assess the shortcomings of each individual component. If some particular amplifier is driven beyond the straight portion of its characteristic we wish to know if it is really worth while to remedy this defect. This defect can be remedied by using a different valve or by increasing the high tension voltage or the grid bias, and so we wish to assess the advantage which will accrue from a given increment of high tension. A direct appeal to experiment, say, by adjusting the grid bias, is often inconclusive. A gross change of grid bias may appear to make no change in the quality or quantity of sound issuing from the loud speaker: how is this to be explained? Perhaps the ear of the experimenter is insufficiently trained to detect the change; so he will probably interest the attention of someone who is a good instrumental performer and who must therefore have an ear at least as well trained as one who is not a performer. If the trained ear gives a verdict of a big change which we do not perceive we may perhaps suspect his perception of change is not such as would be recognised by insentient pointer readings. A private and undivulged check experiment on the expert ear often confirms this view and then the experimental physicist longs inwardly for the hard and cold comparison of figures. Suppose the trained ear agrees that there is no noticeable change when we know with certainty that the factor varied is increasing the distortion: how shall we explain this? Shall we presume that imperfections must be very gross before they become apparent to the human ear, or shall we presume the imperfections were not gross after all? Or shall we presume that the factor we varied did indeed add many fresh notes which were negligible in the ocean of untruths contributed by several other parts of the complete apparatus? In striving to improve the performance of the whole apparatus we require a figure of merit for each part. This paper deals with a stage of resistance-coupled amplification and shows how to measure the distortion it produces. The manner in which a given measure of distortion will appeal to some particular human ear, must be left to the individual judgment of each reader.

*MS. first received by the Editor, Aug., 1929, and finally accepted Oct., 1930.

(2) The Amplifier and its Static Characteristic.

The type of amplifier considered is depicted diagrammatically in Fig. 1 and the values marked are those used in the experimental work: the valve used was a D.E.5 B.

If we plot a curve connecting I_a and v_g for a given value of V_a, we obtain a certain static characteristic for the particular valve and for the particular anode resistance used. Four such characteristics are shown in Fig. 2. Characteristics such as those of Fig. 2 are well known and require little comment: we see that increasing V_a is substantially equivalent to shifting the curve bodily to the left combined with an increase of saturation current. If capacity effects are ignored, the characteristics of Fig. 2 will be followed when v_g is varied in some cyclic or simple

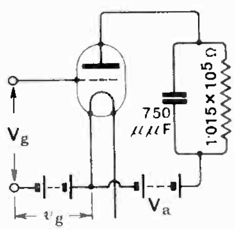


Fig. 1.

harmonic manner. Therefore the same curve is applicable to alternating conditions because the anode impedance is not a function of frequency. In this paper the effect of valve capacities and self-capacity of the anode resistance are ignored because we are studying the distortion due to curvature of the characteristic: it is well known that these capacity effects may be ignored except for very high acoustic frequencies. (*Note.*—The condenser of $750\mu\mu$F. was provided only as a by-pass for radio frequencies, which would be present in the normal service of the amplifier.)

Now let us study the curve of Fig. 2 which relates to $V_a = 225$ v. It appears to be straight within the range $v_g = \pm 5$ v. If, therefore, we start with a grid bias of zero and apply a simple harmonic voltage of 5 v. maximum (3.55 v. R.M.S.) we shall sweep the anode current proportionally up from 1.525 mA. to 2.14 mA. and from 1.525 mA. down to 0.90 mA. the anode current will therefore rise above and fall below its mean value by 0.62 mA. and this flowing through $1.015 \times 10^5\,\Omega$ will cause the anode potential to fluctuate by $\pm$ 63 v. for a grid fluctuation of $\pm$ 5 v. Within this range the amplification is 12.6 and is distortionless. Now suppose we start with a grid bias of -4 v. and apply a simple harmonic voltage of 8 v. maximum, then the anode current will increase by 1.02 mA. and decrease by 0.81 mA. The amplification is now 12.6 for the positive half wave and 10 for the negative half wave and the output is distorted, but how can this distortion be measured in terms of harmonic amplitudes? But we have not considered the circumstances quite accurately, because the anode resistance will be shunted by a grid leak of about 0.5 m Ω connected through a capacity of negligible impedance. In effect this reduces the anode circuit impedance to $83 \times 10^3\,\Omega$ for the alternating components of anode current. Since the positive half cycles of anode current are larger than the negative half cycles, the mean anode current will increase. The change of anode current which results from applying a certain harmonic voltage to the grid, may be analysed into an enhanced mean value and harmonic components. The net voltage drop in the anode resistance is that due to the enhanced mean value flowing through $100 \times 10^3\,\Omega$ plus the harmonic components flowing through $83 \times 10^3\,\Omega$. If we ignore the small effect due to the anode resistance being shunted by the succeeding grid leak, we may use the static characteristic to obtain a measure of the distortion in terms of the positive and negative peak values. This may be understood by reference to Fig. 3. Let DAE be a static characteristic, such as one of those in Fig. 2. Choose a grid bias such as OB and draw BC vertically cutting the curve in C. Draw CX' parallel to OX and replot the portion CE, which is below CX', above CX' as shown by CF. In other words, take the portion $X''CE$, pivot it about the point C and revolve it until CX'' lies along CX'. Then for a harmonic voltage, having a maximum value BV, applied to the grid, the anode current will have a positive maximum measured by KH and a negative maximum measured by KG. The writer has tested this experimentally by connecting across the anode resistance his thermionic voltmeter which measures peak values (see *Journal I.E.E.*, Vol. 66, p. 886). The results of

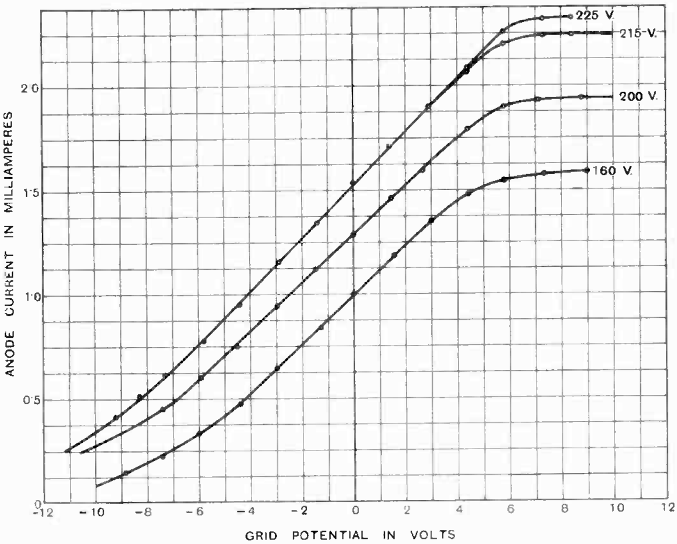


Fig. 2.—*Valve D.E.5B through* $1.015 \times 10^5\,\Omega$.

these experiments are shown collected in Table 1 below: the voltage applied to

TABLE 1.

1	2	3	4	5	6	7	8
V_g	Mean I_a	$V+$	$V-$	i_a+	i_a-	$V+$	$V-$
14.1	1.23	110	98	1.17	?	119	
11.3	1.20	109	94	1.17	?	119	
8	1.17	96	81	0.98	0.9	100	91.5
5.6	1.15	71	64	0.71	0.69	72	70
2.8	1.14	36	34.5	0.34	0.34	34.6	34.6
0	1.13	0	0	0	0		

the grid had a frequency of 90 cycles/sec. and the values of V_g shown in column 1 of the table are $\sqrt{2}$ times the R.M.S. voltage applied.

The grid bias was -2.9 V.: the values of i_a+ and i_a- shown in columns 5 and 6 are the increases and decreases measured from the curve $V_a = 225$ V. of Fig. 2. The values of $V+$ and $V-$ shown in columns 7 and 8 are arrived at by multiplying i_a+ and i_a- by $101.5 \times 10^5\ \Omega$. Columns 7 and 8 should agree with columns 3 and 4, but in fact the predicted values are rather large. Let us make a rough correction for the rectification effect combined with the shunting effect of the succeeding grid leak. When $V_g = 14.1$ V. the mean anode current has increased by 0.1 mA. and so we should use the curve for $V_a = 215$ V. instead of keeping to the curve $V_a = 225$ V. If this is done we find i_a becomes 1.095 mA. instead of 1.17 mA. and hence the predicted value of $(V_a +)$ is 111 V. which is in good agreement with the measured value of 110 V. So it seems the observed values are in good agreement with those predicted by the method described by Fig. 3, provided a small allowance is made for the change of anode circuit resistance. A test with the grid bias at -4.3 V. gave equally satisfactory agreement.

(3) Analysis of the Curves.

An inspection of Fig. 2 will show that the static characteristics show a marked tendency to skew symmetry about their straight portion. Thus in reference to Fig. 3 there exists some point C for which $CAGF$ and $CAHD$ would coincide. The curve in Fig. 2 for $V_a = 225$ V. conforms least well to this condition for there the upper knee is very sharp. The skew symmetry implies that the curve can be expressed by a power series of v containing only odd powers. The curve for $V_a = 200$ V. is represented very closely by the equation

$$i = 1.175 + 0.1372\,v - \frac{5.25}{10^4}v^2$$

if the origin is shifted to the left by one volt negative. As a test of this equation suppose $v = -8$ V., then the calculated value of i is 0.343 mA. and the value read from the curve is 0.33 mA.: when $v = 8$ V. the calculated current is 2.01 and the value from the curve is 2.02 mA. Accordingly we presume the equation to the static characteristic is of the form

$$i = a + bv + cv^3 \qquad \ldots \quad (1)$$

when the origin is chosen properly: this origin does not necessarily coincide with zero

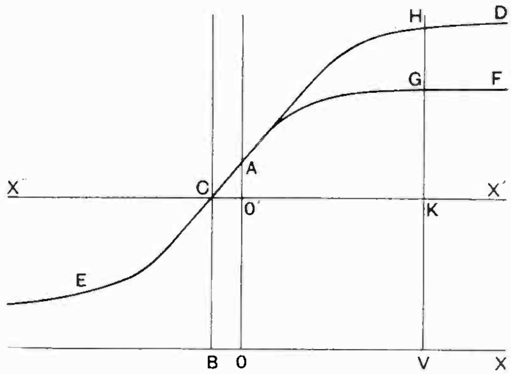


Fig. 3.

grid potential, for example, it is -1 V. in Fig. 2 for $V_a = 200$ V. In this equation we have $c/b \doteqdot 4/10^3$ for the type of valve examined. Now shift the origin to the point $(d, 0)$: in other words, provide a bias voltage d which may be positive or negative. Then we have

$$i = (a + bd + cd^3) + (b + 3cd^2)\,v + 3cdv^2 + cv^3 \qquad \ldots \quad \ldots \quad (2)$$

In this put $v = V \sin pt$, and we have

$$i = \left(a + bd + cd^3 + \frac{3cdV^2}{2}\right) + \left(b + 3cd^2 + \frac{3cV^2}{4}\right)V \sin pt - \frac{3cdV^2}{2}\cos 2pt - \frac{cV^3}{4}\sin 3pt \quad \ldots \quad (3)$$

The rectified current is proportional to V^2: so over the very large range covered by equation (2). the anode resistance does not tend to make the rectified current proportional to V. The term $\sin pt$ is not strictly proportional to V and a second and third harmonic are introduced. Necessarily c is negative and in practice we are interested only in negative values of d. Hence the output current is the combination of the harmonics shown in Fig. 4. Denote by A_2 and A_3 the amplitudes of the second and third harmonic and then we have from (3)

$$A_3/A_2 = \frac{cV^3}{4} \times \frac{2}{3cdV^2} = \frac{V}{6d}$$

So the relative amplitudes of the second and third harmonics do not depend on the coefficient c although the actual amplitudes do depend on this coefficient.

Now $\quad (i_a +) = A_1 + A_2 + A_3$

and $\quad (i_a -) = A_1 - A_2 + A_3$

therefore $\quad A_2 = \dfrac{(i_a +) - (i_a -)}{2}$

and $\quad A_1 = \dfrac{(i_a +) + (i_a -)}{2} - A_3$

Refer again to Fig. 3: we have

$$(i_a +) - (i_a -) = GH$$

$$\therefore \quad A_2 = \frac{GH}{2}$$

and $\quad A_3 = \dfrac{V}{6d} A_2 = \dfrac{BV}{6BO} \cdot \dfrac{GH}{2} = \dfrac{BV \, . \, GH}{12BO}$

(*Note*: We must remember in the above that we presume O is the origin which leads to equation (1) whereas Fig. 3 is supposed drawn from any origin.)

We will now use Fig. 2 and Table 1 to calculate the amplitude of the second and third harmonics for different applied voltages. We will use the amplitudes measured by the peak voltmeter, but if such is not available the whole may be derived from the static characteristic. To make the curve of Fig. 2 for $V_a = 215$ v. conform best to the skew symmetry we must take the origin at -1.5 v. The grid bias for Table 1 was -2.9 v. reckoned from zero grid potential and so we shall take $d = -(2.9 - 1.5) = -1.4$ v.

Though the difference of positive and negative maxima suggests the distortion is very gross, yet we find the second harmonic never reaches 9 per cent.: the second harmonic being a true octave of the fundamental is presumably not very damaging to the tone. The third harmonic, which is a false note, does not exceed about 5 per cent. and possibly this is not enough to be very serious. At any rate the amplifier should function well with this grid bias for grid swings up to ± 8 v., whereas a casual inspection of the characteristic would suggest that the limit was a swing of about 4 v. So the writer suggests that amplifiers may be used properly with an input much greater than would be indicated by the scope of the straight portion of the characteristic. Repeating the process for a grid bias of -4.3 v. we will see whether this increases the distortion appreciably.

TABLE 2.

V_g	$V+$	$V-$	$\dfrac{(V+)-(V-)}{2}$	$\dfrac{\{(V+)-(V-)\}V_g}{12 \times 1.4}$	$\dfrac{(V+)-(V-)}{2} - A_3$	$A_2\%$	$A_3\%$	μ
14.1	110	98	12	5	99	6.1	5	7
11.3	109	94	15	5	96.5	7.8	5.2	8.5
8	96	81	15	3.5	85	8.8	4.1	10.6
5.6	71	64	7	1.15	66.4	5.3	1.7	10
2.8	36	34.5	1.5	0.124	35	2.1	0.35	12

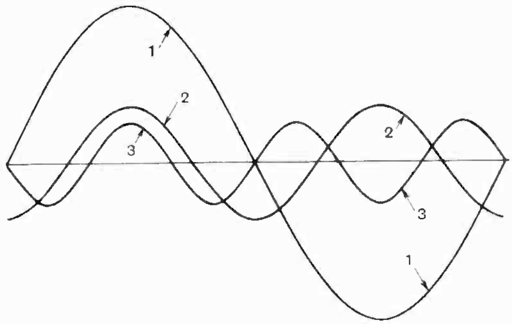


Fig. 4.

We now have $d = -2.8$. The results are shown in Table 3 below.

Comparing Table 3 with Table 2, we see the extra negative grid bias of 1.4 v. leaves the fractional amplitudes of the harmonics substantially unchanged so long as the grid swing is less than $\pm$ 8 v. This explains why a change of grid bias often makes no apparent difference to the output of the loud speaker even though we know it has made the amplifier function over a much more curved characteristic.

TABLE 3.

V_g	$V+$	$V-$	A_1	A_2%	A_3%	μ
14.1	116	94	97	12.4	9.5	6.9
11.3	115	88	92	14.4	9.8	8.1
8	92	74	78.7	11.4	5.5	9.8
5.6	67	59	61.7	6.5	2.1	11
2.8	33	31	32	3	0.5	11.4

In general the grid of such an amplifier will be fed through a condenser and the grid potential will be applied through a high resistance grid leak. When the positive grid swing exceeds the negative grid bias, grid current will flow: this makes no difference to the foregoing analysis so long as a grid leak is not present. But if there is a grid leak the rectified grid current will depress permanently the grid potential and be equivalent to increasing the negative grid bias by an amount which depends on the applied voltage. Table 4 shows the observed values of $(V+)$ and $(V-)$ when the grid was connected to the bias battery through a leak of 0.5 mΩ and fed through a condenser of 0.01μF capacity: the grid bias was maintained at -4.3 v.

TABLE 4.

1	2	3	4	5	6
V_g	I_amA.	I_g μA.	$4.3+I_gR$	$V+$	$V-$
14.1	0.72	11.8	10.2	109	58
11.3	0.74	8.3	8.5	98	60
8.0	0.85	4.0	6.3	84	62
5.6	0.96	1.0	4.5	65	56
2.8	0.10	0	4.3	33	31
0	0.98	0	4.3	0	0

Comparing columns 5 and 6 of Table 4 with columns 2 and 3 of Table 3, we see in Table 3 that $(V+)$ comes to a limiting value when V_g exceeds about 10 v., whereas in Table 4, $(V+)$ is still increasing roughly in proportion to V_g over the whole range measured: the opposite is the case with $(V-)$. The reason for this is clear when we consider Table 4 in conjunction with Fig. 2: for example take $V_g = 14.1$. Column 4 of Table 4 shows that the rectified grid current has increased the grid bias by 5.9 v. and so brought the grid potential to -10.2 v. Fig. 2 shows that by starting at -10.2 v., it would be necessary for the grid swing to exceed 16 v. before raising $(V+)$ to the limiting value of $(2.32 - 0.35) \times 1.015 \times 10^2 = 200$ v., whereas $(V-)$ could not exceed 35 v. Thus the reason why the grid leak increases the values of $(V+)$ and decreases those of $(V-)$ is quite clear from a survey of the static characteristic, but the general complexity of the problem renders it very troublesome to predict values from the static curve. But half the difference between the observed values of $(V+)$ and $(V-)$ will still give a measure of the second harmonic. It is evident that grid rectification and the grid leak increases the distortion from the amplifier, but we have considered only sustained harmonic voltages, whereas in broadcast reception a given note is not long maintained. The time constant of the grid leak circuit must be large so as to pass low acoustic frequencies to the amplifier. Let us suppose a very large grid condenser and that we have $V_g = 14.1$ according to Table 4. If the applied voltage is suddenly switched off the alternating fluctuation of anode current would cease instantly, but the mean grid potential would fall very slowly from -10.2 v. to -4.3 v.: this will cause a corresponding slow transient of anode current which would have been absent except for grid rectification. So it seems desirable to limit the peak value of the input voltage to the value of the grid bias, but within limits an increase of input can be dealt with safely by increasing the grid bias, and these limits can be assessed by the methods we have described.

(4) Production of Combination Tones.

We must now consider the effect of applying simultaneously two harmonic voltages to the amplifier; thus suppose we have

$$v = A \sin pt + B \sin qt$$

If we substitute this value of v in equation (2) we find that

$$i = \left(a + bd + cd^3 + \frac{3cdA^2}{2} + \frac{3cdB^2}{2}\right)$$
$$+ \left(b + 3cd^2 + \frac{3cA^2}{4} + \frac{3cB^2}{2}\right) \sin pt$$
$$+ \left(b + 3cd^2 + \frac{3cB^2}{4} + \frac{3cA^2}{2}\right) \sin qt$$
$$- \frac{3cdA^2}{2} \cos 2\,pt - \frac{3cdB^2}{2} \cos 2\,qt$$
$$- \frac{cA^3}{4} \sin 3\,pt - \frac{cB^3}{4} \sin 3\,qt \quad .. \quad (4)$$

So the fundamental of the first note alters the fundamental of the second note by means of a term of the form $3cB^2/2$: since c is negative this is equivalent to reducing the amplitude, and since the second and third harmonic terms are not mutually affected the second note does in fact increase the fractional distortion of the first note. But the matter does not end here for in addition we find combination terms are produced and to complete equation (4) we must add

$$i = 3cAB[d\{\cos (p - q)t - \cos (p + q)t\}$$
$$- \tfrac{1}{4}\{A \sin (2p + q)t - A \sin (2p - q)t$$
$$+ B \sin (2q + p)t - B \sin (2q - p)t\}] \quad (5)$$

We have here six new tones which are not harmonics of either original note. If A and B are about equal, then the tones $(2p \pm q)$ and $(2q \pm p)$ will be about three times as strong as the third harmonic of the separate original tones, and so in this respect the value of the third harmonic deduced from the static characteristic does become a very important factor for estimating the distortion of output. The tones $(p \pm q)$ are directly proportional to d and are therefore increased by increasing the negative bias. If d is made zero these terms are zero. Therefore it would seem that the most desirable grid bias is that which corresponds to the centre of skew symmetry of the static characteristic. If this bias is chosen there will be no second harmonics of either note and no combination tones of frequency $(p \pm q)$.

Applying this analysis to the curve for $V_a = 200$ in Fig. 2 with $d = O$, that is $v_g = -1$. If the peak voltage of a single note is 8, then it may be found from equation (4) that the third harmonic is 16 per cent. and the second harmonic is zero. If we now apply in addition a voltage $8 \sin qt$ then it may be found that the third harmonic of $\sin pt$ and of $\sin qt$ rises to 23.6 per cent. and also there are combination tones $(2p \pm q)$ and $(2q \pm p)$ each of which has an amplitude which is 70 per cent. of the fundamental amplitudes of the notes p and q. Though each note has an amplitude of 8 v., which is perhaps not unduly excessive for this amplifier, yet there are moments when the grid swing is ± 16 v. which is, of course, vastly more than the amplifier can cope with. If grid leak rectification were also occurring conditions would be much worse and the tone $(p \pm q)$ would appear.

(5) Summary.

This paper describes a method of predicting from the static characteristic the output of a resistance coupled amplifier. A certain form of equation is assumed for the characteristic and this leads to simple rules for deducing the fractional amplitudes of the second and third harmonic currents which are produced by the curvature of the characteristic. The form of the equation is supported strongly by the shape of the characteristic, but it may be seen that a small departure from this form of equation would not alter the circumstances appreciably. It seems probable the output can be analysed into a Fourier series by the methods described with at least as much accuracy as could be obtained from any oscillograph method. It appears that the straight portion of the characteristic may be departed from appreciably and yet very small distortion introduced thereby. At any rate, it is a simple matter to describe in terms of Fourier coefficients the distortion which does result from a given departure from linearity.

The Losses in Variable Air Condensers.*

By W. H. F. Griffiths, F.Inst.P., A.M.I.E.E.

IN the Correspondence columns of the April, 1930, issue of this journal are given two methods of forming an expression for the series resistance of a variable air condenser equivalent to the dielectric loss occurring in the solid dielectric material used in its construction. The first method—favoured by J. M. Miller, of Philadelphia—involves a somewhat roundabout process of reasoning, and even that given by the Editor in his reply can, in the author's opinion, be still further simplified by omitting all reference to voltage or current, the reasoning being based merely upon the impedance (vector) triangle of a capacity and resistance (equivalent) in series which gives to a high degree of approximation for condensers with which one is, in practice, likely to meet, the well-known simple expression for power-factor $\cos\phi = R\omega C$.

It is immediately obvious that the resultant power-factor of a variable condenser at any setting due to the dielectric loss in the solid insulating material used in its construction is that of the material itself diluted C/c times by the pure air capacity $C - c$ where C is the total capacity of the condenser at any setting and c is the *constant* capacity due to the electric field through the solid insulating material.

$$\text{P.F. of } C = \frac{c}{C} \cdot \cos\phi = R_\phi \omega C$$

$\therefore$ The equivalent series resistance

$$R_\phi = \frac{c \cdot \cos\phi}{\omega C^2} \quad \ldots \quad \ldots \quad (1)$$

The term $c \cdot \cos\phi$ is proportional to the power-loss factor of the material, *i.e.*, to the product of its permittivity and its power-factor. With varying frequency this product is often more constant than the power-factor itself—in some Bakelites and loaded ebonites it is practically constant throughout the range of frequencies 10^3 to 10^6 per second. It requires no further thought, therefore, to see that

$$R_\phi = \frac{a}{\omega C^2} \quad \ldots \quad \ldots \quad (2)$$

where a is a constant proportional to the power-loss factor of the material.

As pointed out in the Editorial of the issue of December, 1929, the actual conductor resistance R_s varies but little over a wide range of frequencies, but there is another component of the effective resistance of a condenser which, whilst negligible at the higher radio-frequencies, often makes a serious contribution to the total losses at carrier and speech frequencies—the insulation resistance. This fault may be due to conductance over the surfaces of the solid dielectric material or to foreign matter in the air gaps between the two plate systems. The latter cause may be eliminated by careful cleaning and if this is done the insulation resistance is constant for all values of C, and so the series resistance R_p

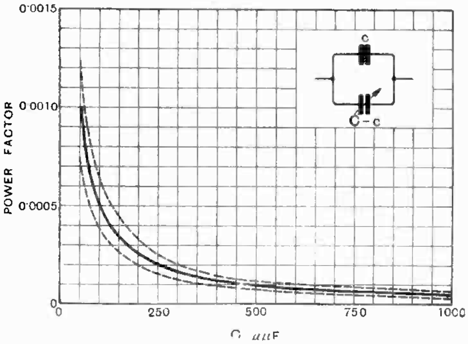


Fig. 1.—*The power-factor of a variable air condenser due to the dielectric loss in* 10μμF. *of solid insulating material of* 0.005 *power-factor (good ebonite). The conductor resistance is assumed to be zero and the insulation resistance to be infinity. The broken line curves show the probable limits of the variation of power-factor with extreme changes of frequency.*

equivalent, in effect, to this parallel resistance may be written

$$R_p = \frac{1}{\beta\omega^2 C^2} \quad \ldots \quad \ldots \quad (3)$$

where β is a constant (the insulation resistance).

The complete expression for the effective resistance of an air condenser now becomes

$$R = R_s + \frac{a}{\omega C^2} + \frac{1}{\beta\omega^2 C^2} \quad \ldots \quad \ldots \quad (4)$$

* MS. received by the Editor, May, 1930.

the term containing ω^2 in the denominator obviously becoming rapidly negligible with ascending frequency.

In wireless work the losses of a condenser

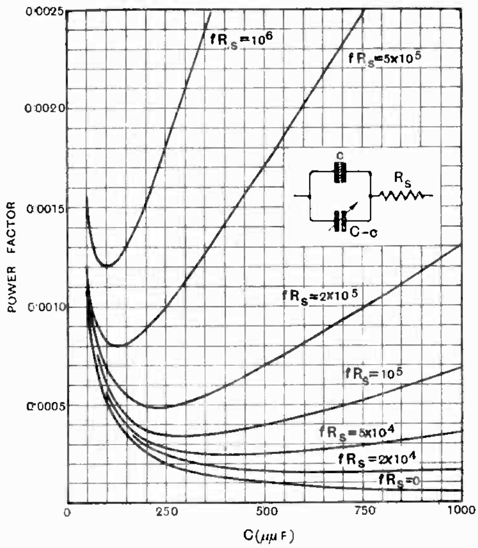


Fig. 2.—*Showing the effect of series resistance upon the power-factor of a variable air condenser. The curves are plotted for various values of the product of frequency and series resistance—that for $fR_s = 0$ being the power-factor due to the solid dielectric only as given in Fig.* 1.

have usually to be added to those of an inductance with which it is invariably associated in a resonant circuit. The losses of the inductance coil are collectively stated conveniently as effective (series) resistance at a given frequency, and so it is convenient also to collect the three forms of condenser loss into one quantity—the effective resistance—which may be added arithmetically to that of the inductance and to the resistance of any other apparatus or leads with which the circuit is completed. This collection of losses is, of course, effected in the expression (4) above. The total effective resistance R at a given frequency will not, however, convey, at a glance, the quality of a condenser. It is obvious that a much truer idea of the efficiency of the essential components of an oscillatory circuit (whether condensers or inductances) will be given by a statement of the ratio of resistance to reactance, *i.e.*, by power-factor.

The lowest power-factor that it is possible to obtain in a variable condenser of a given construction (when $R_s = 0$ and $r = \infty$) is that which is due to the dielectric loss inherent in the solid insulating material employed in such construction. The first and third terms in expression (4) are in this case zero, and the second term alone governs the power loss. The power-factor due to this cause varies throughout the range of the condenser* as shown in Fig. 1, and is of a constant *order* throughout the whole range of frequencies for a given quantity and disposition of solid insulating material. It is, in fact, as independent of frequency as the power-loss factor of that material, and even with the maximum variation to be expected in ordinary insulators the curve will remain within the limits indicated.

In Fig. 2 is shown the effect of series resistance R_s upon the power-factor of this condenser with varying frequency, the minimum power-factor when $fR_s = 0$ being the basic curve of inherent power-loss of Fig. 1.

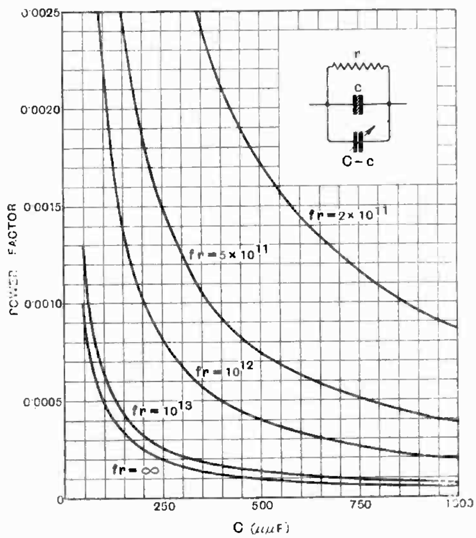


Fig. 3.—*Showing the effect of parallel resistance (insulation) upon the power-factor of a variable air condenser for various values of the product of frequency and resistance. The basic curve plotted for $fr = \infty$ is that due to the losses in the solid dielectric material only as shown in Fig.* 1.

The curves of Fig. 3 show the effect (upon

* The example taken here is an ordinary 1,000μμF. variable air condenser with ebonite separation between the plate systems. The capacity due to the electric field actually passing through the ebonite is assumed to be 10μμF.

the same condenser) of parallel (insulation) resistance with varying frequency, the minimum in this case also being the curve of Fig. 1, where $fr = \infty$ owing to the assumption of perfect insulation.

A variable condenser wh e inherent loss due to solid dielectric material is reasonably low may be faulty owing to a high series resistance somewhere in the conductor systems and/or to a low insulation resistance consequent upon leakage over a damp or unclean insulator. Taking, as an example, the highest series resistance and the lowest insulation resistance with which one is likely to meet in practice, it is extremely interesting and useful to find the lowest and highest

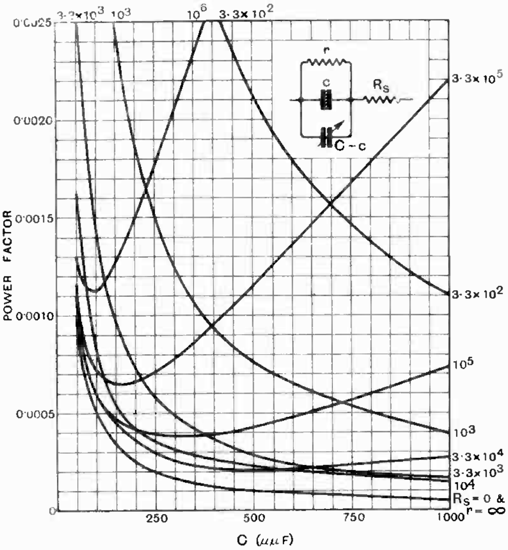


Fig. 4.—*Curves showing the effect of frequency upon the power-factor of a variable air condenser having faulty insulation and high conductor resistance. The values of* R^s *and* r *have in this example been taken as* 1 *ohm and* 5×10^8 *ohms respectively, since this represents the worst case with which one is likely to meet in practice. The minimum power-factor curve plotted for* $R_s = 0$ *and* $r = \infty$ *is the same as that of Fig.* 1.

frequencies respectively at which these sources of loss become appreciable. The curves of Fig. 4 show that the series resistance is appreciable for frequencies above 10^4 per second and the parallel resistance becomes appreciable for frequencies below this.

The frequency at which the total loss from all sources is a minimum, varies throughout

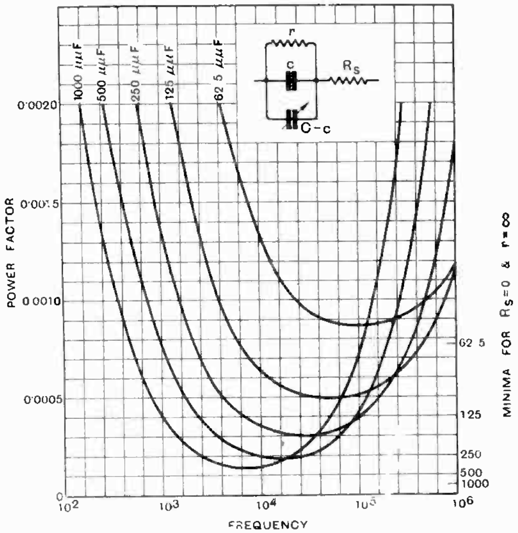


Fig. 5.—*Showing the variation of power-factor with frequency of a variable condenser having* 10μμF. *of* 0.005 *power-factor solid dielectric material and in which* $R_s = 1$ *ohm and* $r = 5 \times 10^8$ *ohms. Power-factor curves are given for five settings of the condenser.*

the capacity range of the condenser, and the curves of Fig. 5 have been plotted to show this effect. It is seen that for every setting of an ordinary variable air condenser there is a particular frequency or range of frequency at which the dielectric loss of the solid insulating material employed is not augmented to any serious extent by either high conductor resistance or faulty insulation resistance. This is, of course, only true of ordinary condensers of reasonably low-loss design, and is not true of special low-loss designs in which the solid dielectric material is of especially good quality and is limited in quantity.

Although all the curves given in this article have been plotted from computations of theoretical examples they will be found to approximate to actual condensers of an average laboratory grade.

Further Advances in the Technique of the Braun Tube.*

By Manfred von Ardenne (Berlin)

THE writer has already published in this Journal† details of a new Braun tube which permitted photographic recording of comparatively rapid phenomena. For many purposes, as, for example, when the tube is used as a valve voltmeter, for making continuous measurements, or for demonstration, photographic recording is not practicable. In such cases a fluorescent screen of zinc silicate is used, as this gives considerable visual intensity. For applications of the type mentioned a smaller Braun tube, with but a single pair of deflecting plates, has been developed. The construction of the small tube is shown in Fig. 1, in which, for the sake of comparison, the larger tube is also depicted. As a result of the high energy of the ray, which is provided by using anode potentials of the order of 1,000 volts, the fluorescent light is intense enough to permit many observations to be made even in daylight. The advance offered by the smaller tube is primarily a commercial one. It possesses a rather higher sensitivity than the larger tube, this being conferred by the use of longer deflecting plates.

In order to make the Braun tube into a technical measuring instrument that can be used where previously valve voltmeters and other alternating current instruments have held the field, it must be made possible to heat the filament with alternating current. In all Braun tubes which have so far been commercially obtainable, any attempt at heating the cathode by alternating current has always resulted in an appreciable deviation of the ray. This disturbance is caused by the magnetic field surrounding the cathode. It can be reduced, according to a proposal made by H. von Hartel, by making the cathode in the form of a loop. As the change is concerned entirely with an alteration in the physical shape of the wire,

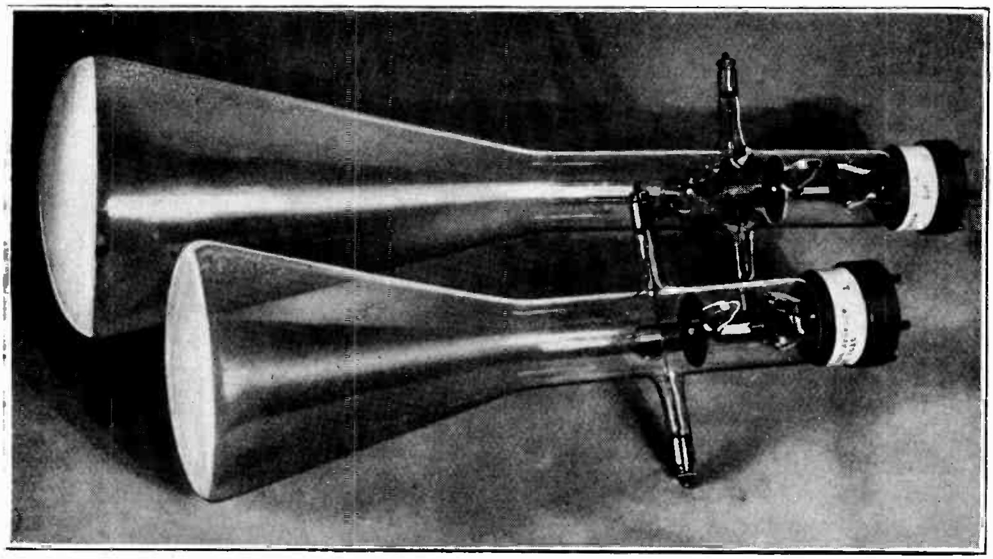


Fig. 1.—*Cathode-ray tube for photographic recording, with the new small type for visual observation.*

* MS. received by the Editor September, 1930.

† A Braun Tube for direct photographic recording. *E.W. & W.E.*, February, 1930.

which requires no higher current than the older type of cathode, it is clear that direct current can be used exactly as formerly. By suitably disposing the filament leads the magnetic field at the tip of the filament can

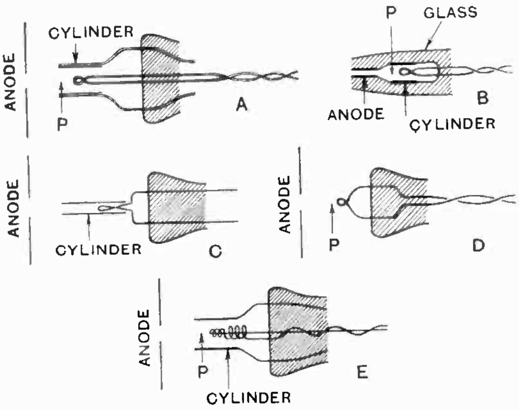


Fig. 2.—*Forms of cathode suitable for heating by alternating current.*

be exactly counterbalanced by the field due to the larger, but more distant, loop in the filament. In practice it depends upon making the alternating magnetic field due to the heating current as small as possible in the zone where the electrons move with the smallest velocity. With the arrangement of electrodes described earlier, as used in the author's tubes, a negatively-biased cylinder symmetrically surrounded the cathode. This cylinder provided for concentrating the beam, and withdrew positively-charged gas ions from the cathode. To this last effect the tube was indebted for the long life of its oxide-coated cathode, even when using high anode voltages.

With the shielded arrangement of the electrodes the region of minimum potential lies near the opening of the cylinder. The loop in the filament has to be so dimensioned that the magnetic field is as completely balanced out as possible for this zone. Various arrangements of the electrodes which permit such compensation are shown diagrammatically in Fig. 2. The region for which the magnetic field must be compensated as fully as possible is indicated by the letter *P* in this illustration. The arrangement shown in Fig. 2A is that actually used in the new Braun tubes. Fig. 2B shows the arrangement which would permit A.C. heating in, for example, the Western Electric tube. In Fig. 2E the simple principle is shown in application to a spiral cathode. It is, of course, necessary to take care that the compensation is not upset by those parts of the filament leads that are external to the tube ; a bifilar arrangement of these leads is satisfactory. The practical form of the universal cathode, as used in the Braun tubes‡, shown in Fig. 1, can be seen in the photograph (Fig. 3), in which the Wehnelt cylinder is cut away on one side.

Two types of supply-unit, both for A.C. mains, have been developed for the new Braun tubes ; they both supply filament current as well as the necessary voltages for anode and cylinder. They are connected directly to the usual 110-volt or 220-volt mains. The inevitable variations in voltage do not noticeably affect the working or the sensitivity of the tube. The small model

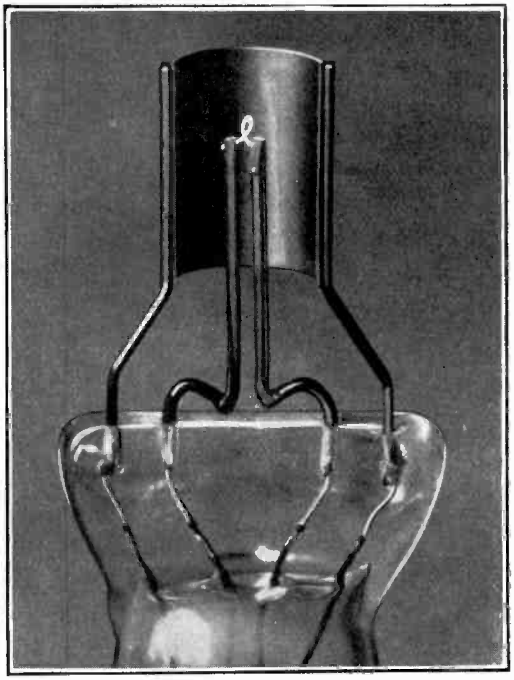


Fig. 3.—*Appearance of the universal cathode.*

provides an anode voltage a little greater than 1,000 volts, but the other model,

‡ These tubes are put on the market by E. Leybold's Nachfolger A.G., of Bayenthal, Cologne, Germany.

which provides power enough for photographic registration, is more interesting. This unit, the circuit of which is given in Fig. 4, provides at choice anode voltages of 1,500 or 3,000 volts. It is very advantageous to have the two voltages at one's disposal, for the higher voltage, which puts a greater load on the cathode, is almost always needed only for the short time during which the photographs are being made. In the model shown the cylinder voltage automatically adjusts itself as the switch is turned to alter anode voltage. Fine adjustment of the cylinder voltage so as to give best concentration of the beam is effected by the high resistance R. In order to set in operation a Braun tube equipment set up on the lines described, it is only necessary to switch on the current from the mains.

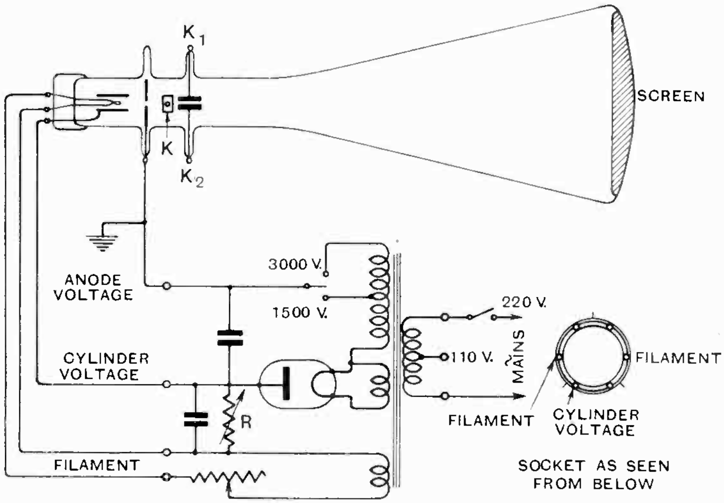


Fig. 4.—*Complete circuit of the new cathode-ray equipment.*

Some Measurements of a Loud Speaker *in Vacuo.*

Paper by Mr. P. K. Turner, M.I.E.E., read before the Wireless Section, I.E.E., on 4th February, 1931.

ABSTRACT.

THE paper opens by referring to the difficulty of interpreting results obtained by measurement of the actual acoustic output of a loud speaker, while pure analysis would indicate that the ordinary moving-coil speaker cannot be useful at frequencies of over say 800 c/s ($\omega = 5{,}000$).* The author was therefore led to the method of checking some of the fundamental data by measurements made under three conditions:—first with the coil firmly held so that the impedance of the coil itself *in situ* could be found; secondly with the whole instrument in a vacuum chamber, this giving an impedance depending only on (a) the coil impedance already found and (b) the mechanical impedance of the moving parts, which can then be computed; thirdly under normal conditions, when is added an acoustic impedance which can, in turn, be computed by allowing for the impedances already found.

By analysis of the results one should be able not only to complete the "response" curve of the speaker but also to show whether any deviations from the ideal arise from electrical, mechanical or acoustical defects. The latter information can in no way be obtained from a response curve directly measured.

The measurements bring to light some interesting points, especially as to the means by which a reasonable output is obtained at high frequencies. Some of the more striking results are summarised in the paper:—

(1) The inductance of the coil falls considerably as the frequency goes up, eventually becoming less than its value for the coil in air. This is due, apparently, to the "short-circuited secondary" effect of eddy currents in the iron in its neighbourhood.

(2) The effective mass (both mechanical and acoustical) of the moving parts also falls off very considerably as the frequency rises. In this case the apparent mechanical mass decreases from 21 grammes to about 10 grammes for a frequency as low as 800 c/s.

(3) The measured acoustic resistance *does not* fall off, and at all frequencies exceeds the theoretical radiation resistance of a rigid disc of the same diameter.

(4) Wave transmission down the cone becomes important at quite low frequencies, its effects being perceptible in this case at 300 c/s.

(5) At low frequencies about three-quarters of the width of the "surround" appears to behave as if it were part of the cone.

The author then deals with the basic analysis, building up from considerations of mechanical impedance and electro-mechanical conversion. The

* *Cf. E.W. & W.E.*, 1929, Vol. 6, p. 353.

basic data available comprise the mass, projected radius of the cone, stiffness of suspension, flux density and length of wire on the coil. The observed values comprise three sets of measured resistance and reactance obtained under the conditions already stated. The measuring equipment is shown in Fig. 2,* being a semi-permanent assembly used for practically all the bridge work of the laboratory. The bridge network itself is of a normal type except that a reversing switch, connected at points A and B, can interchange the two half-primaries of the mutual inductor when it is desired to measure a negative resistance. The Wagner earth is switched in by C. The vacuum chamber and pump are shown in Fig. 3.

In order to avoid accidental divergencies the observed values were first plotted on a large scale and a series of "probability curves" were derived from the curves for values of f giving convenient values of ω. These latter were used as the basis of the succeeding work. Tables of observed and most probable values are given in the paper. On consideration of the data it was decided to compute for a series of angular velocities up to $\omega = 5{,}000$, and then to investigate the possibility of extra polating for higher frequencies. It soon became evident that wave transmission down the cone became the dominating factor in the mechanical impedances at quite low frequencies, symptoms of it being obvious at 500 c/s.

The author then generalises the complex cone system into the electrical-line equivalent of Fig. 7. Discussing the difficulties of applying the parallel, it is pointed out that this line cannot be expected to behave in detail like a normal line, but in the author's opinion the following assumptions are justified :—

(i) At very high frequency the input impedance will tend to constancy. In the case of a normal line it tends towards R=constant, X=o, but in other types of calculable line X also tends towards a constant finite value. (ii) At very low frequencies we may certainly assume "rigid" motion, in which case the input impedance will simply consist of the total R plus the reactance of the total mass. (iii) A rather more speculative assumption is that the first divergence from (ii) as frequency rises will be to a first approximation, of the same type as that for a normal line.

The paper next deals with the results obtained in their relation to electrical and mechanical impedances under the headings of (a) the inductance and resistance of the coil, (b) the mass and stiffness at low frequencies and the force factor, (*c*) the input impedance of the cone as a line. From this it passes to the acoustic impedance, under the headings (*a*) the acoustic mass and effective cone surface, (*b*) the acoustic resistance. It is pointed out that the electrical impedance of the coil itself falls at high frequencies. The apparent mass of the cone, from the input point of view, falls from 16 to 5.37 grammes, and the acoustic resistance falls to far below its value for a rigid disc, in fact all the "masses" giving useless reactance fall as frequency goes up. It is also shown, however, that the useful component of impedance—the acoustic resistance—is in excess of its theoretical value. It must not be assumed, however, that all the power expended in the acoustic resistance is actually used in radiation. Some of it is certainly dissipated in "skin friction" of air about the coil in the gap. It must also be remembered that the cone is not moving normal to its own surface. This means (see Fig. 14) that of the motion of any point O in the cone which is in the direction of OA, only the component OB, normal to the surface, is directly producing radiation. The component OC is producing skin friction. At the same time these "sliding" components of motion, of both coil and cone, must be producing some radiation, since they are doing work on the air, for a body can only do work by air friction if it carries some air with it, and such movements of air themselves set up

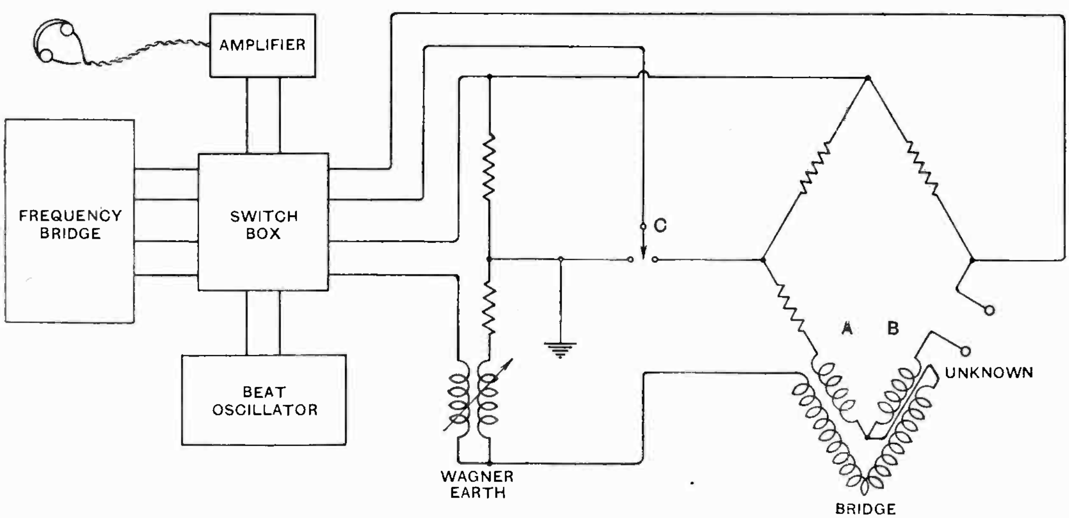


Fig. 2.—*Simplified schematic diagram of the measuring equipment. A and B are connection points for inductometer reversing switch. C is the switch for Wagner earth.*

* The author's original figure-numbers are adhered to throughout this abstract.

radiation. There is also the question whether the total theoretical radiation from a cone is really substantially identical with that of a disc of equal radius. To the best of the author's knowledge no

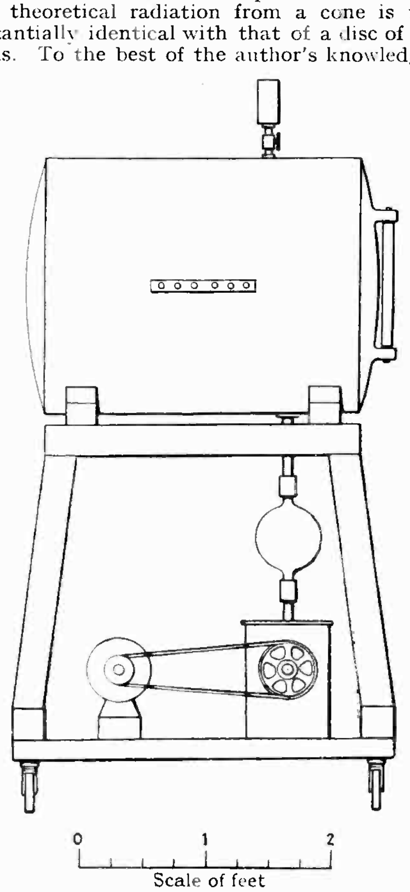


Fig. 3.—*The vacuum chamber.*

analysis of the problem has yet been published. These points are important, as any estimate of radiated power or efficiency depends on them. Obviously the total dissipation must be used in computing the motion of the diaphragm, but only the useful radiation resistance is employed in computing the output power.

The author then proceeds to the collection of the computed data and to extra polation to higher frequencies, deriving curves of mechanical resistance and reactance of the diaphragm, and of the acoustic resistance. These permit re-computation of the electrical impedance of the speaker, as shown in Fig. 17, and the final computation of response curves of output air-pressure, as in Fig. 18, the cases shown being for constant current and constant voltage respectively. It has been impossible for the author to get a final check on the whole argument by having direct a response-curve taken, but he believes that it is substantially in agreement with Fig. 18. The actual purpose of the present paper has been to call attention to the method of measurement, which is believed to be a really useful one. Unfortunately the author has only been

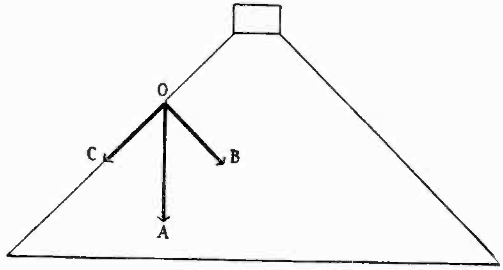


Fig. 14.—*Normal and tangential components of cone motion (see text).*

able to carry out the single series of measurements dealt with in the paper.

Discussion.

The discussion which followed the reading was very long and was, on the whole, adversely critical to the paper.

Dr. G. F. Dutton did not think the cone was a simple transmission line, due to its two degrees of freedom. The efficiency at higher frequencies was largely due to natural modes of vibration. Fig. 18 of the author's paper was not necessarily true in conditions of confined space. More usual types of response-curve were less smooth than those of the author, and a slide was exhibited showing responses of a speaker with a paper and with a buckram diaphragm.

Dr. N. W. McLachlan referred to the fact that no resonances were shown in the results. The smoothing of the observed data had masked physical results, and the number of readings taken was inadequate. It was necessary to take at least 100 readings, or even up to 300, with a free-edged cone. Slides of two response curves were then given, showing sharp resonances about

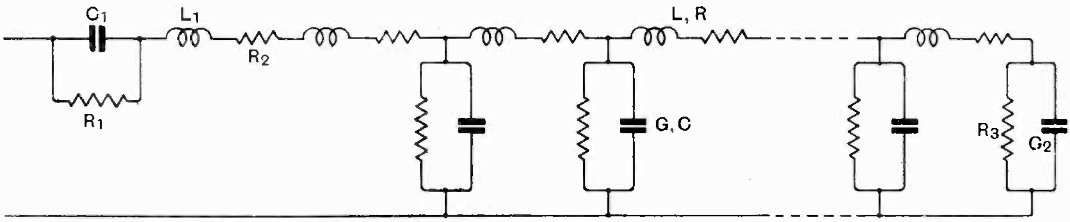


Fig. 7.—*The electrical line equivalent to the cone and its suspension C_1 and R_1 elastance and viscosity of centring washer. L_2 mass of coil and former. R_2 air friction in gap. L, R, C, g line components (L mass of cone and acoustic resistance; C elastance of cone itself: G viscosity in C; C_2, R_3 elastance and viscosity of "surround"). The mass of the surround is neglected, but would appear as an inductance in series with the $C_2 - R_3$ load.*

50 cycles. He severely criticised some of the author's calculations, also the possibility of differences of temperature as between observations and the effect that these might have on errors. He had found resonances on the upper register to be due to flexible modes of the coil and showed a slide illustrating resonances due to the coil alone. His results on both the lower and upper frequencies made it impossible for him to believe that the cone could be treated as a transmission line.

MR. C. B. GARTON said that the results of powder on cones made it impossible to treat the cone as a transmission line. He disagreed from the previous speaker as to the flexure of the coil and attributed the effects to the material of the cone. There would be no progress in design from the paper. The problem was very complex, due to the breaking-up of the cone into vibrating sections. Success in design was to be achieved by more rigidity and he suggested a metallic diaphragm. This was better and more faithful, particularly to transients. Even if a paper and a metal diaphragm gave similar responses to the steady state, the metal was superior for response to transients.

MR. D. A. OLIVER queried the effect of the size of vacuum chamber used. For a "concertina" movement he thought the transmission line was valid, but he did not accept the constants shown by the author. It would be desirable to get measurements with the cone free and with the edge clamped to get the constants.

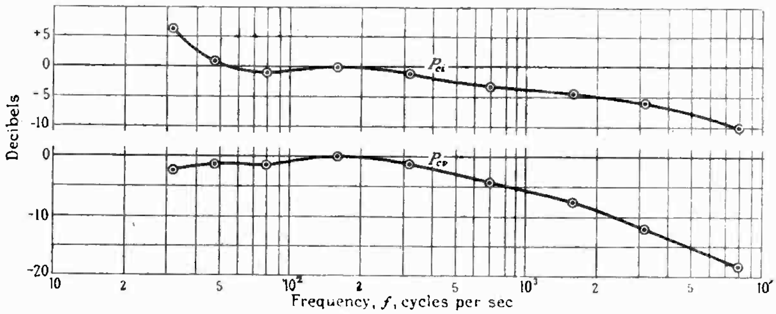


Fig. 18.—*The computed response curves of output air-pressure, plotted against frequency. Referred to zero noise-level at* 1,600 *cycles per sec.*

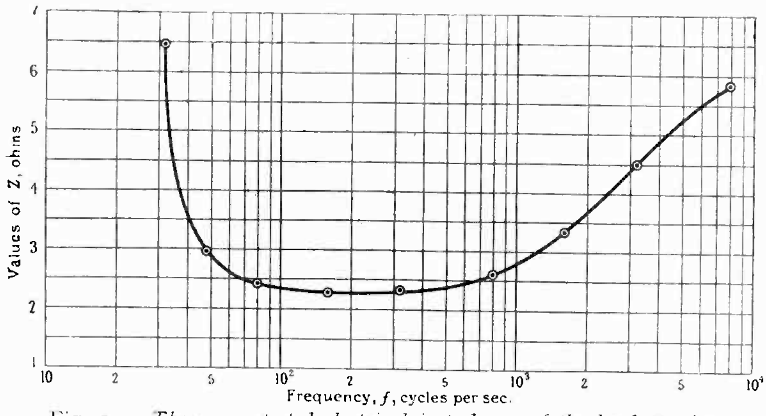


Fig. 17.—*The re-computed electrical impedance of the loud speaker.*

MR. A. G. WARREN criticised the smoothing of the data. Smooth curves were not to be expected. He dealt with the diaphragm from Rayleigh's theory and referred also to the formation of peaks. He did not agree with the application of the transmission line and pointed out that several calculations made on the author's data actually gave negative values of L and C.

MR. N. FLEMING also referred to the smoothing of peaks in the author's response curves. Peaks were undoubtedly lost in the smoothing and extrapolation might be misleading. Recalculating from the author's data he found discrepancies, *e.g.*, at 3,000 cycles his result for the curve P_{cv} was 10 d.b. above that of the author, and at 1,500 and 2,000 negative values were obtained.

MR. A. M. HALLIWELL thought the author would have done better to have started with a horn, but considered that the present method might help to standardise speakers. Response curves were usually taken in front, but measurements made at the side might show a falling characteristic and the position in the room might be quite important.

MR. M. G. SCROGGIE said that the results with the cone "held" approximated closely to those *in vacuo*. He expressed doubts of the method of holding the coil and referred to the known difficulties of effectively clamping the coil. The effects of the room must also influence the speaker impedance.

MR. SOWTER also suggested that the author's method of fixing was not correct, and stated that small changes in the position of the coil made considerable differences in values of X and R. The frequency intervals used by the author were too wide to determine actual performance.

MR. L. E. C. HUGHES suggested that the ratio of acoustic power output to power input should be the standard. He also dealt at some length with radiation in different directions and showed slides giving polar curves of horn, cone, and moving coil speakers.

MR. P. K. TURNER, in replying to the discussion, said that much of the criticism arose because speakers did not appreciate the intention of the paper. He did not claim any excellence of the results shown and referred to the text of the paper where it was stated that they were presented not so much for any intrinsic merits of their own but because they did indicate that this line of attack was a useful and powerful one.

Selectivity and Response.*

By E. E. Wright, B.Sc.

SUMMARY.

This note is an attempt to find from theoretical reasoning the reponse of a selectively tuned circuit to a steadily modulated wave.

1. Introduction.

CONSIDER a series circuit consisting of a resistance R, a self-induction L, and a condenser of capacity C. Suppose an e.m.f. $\hat{e}\cos\omega t$ is induced in this circuit, then the current i is given by

$$i = \frac{\hat{e}\cos(\omega t - \phi)}{Z} \quad \ldots \quad (1)$$

Where

$$Z = \sqrt{R^2 + \left(L\omega - \frac{1}{C\omega}\right)^2}$$

and

$$\tan\phi = \frac{L\omega - \dfrac{1}{C\omega}}{R}.$$

For a variation of ω, $\hat{\imath}$ has its maximum value when $\omega = \dfrac{1}{\sqrt{LC}} = p$ say.

2. Impedance near the Resonating Frequency.

Suppose ω has a value slightly different from p. Thus let $\omega = p + \triangle$. Now remembering that $Lp = \dfrac{1}{Cp}$ and neglecting $\left(\dfrac{\triangle}{p}\right)^2$ compared with unity, we have

$$Z = \sqrt{R^2 + (2\triangle L)^2} \quad (2)$$

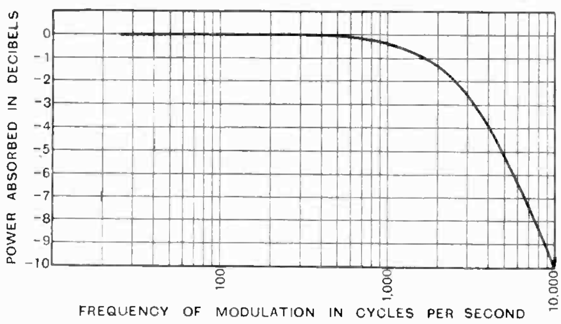


Fig. 1.

3. Measure of Selectivity.

Suppose the circuit to be tuned to a pulsatance ($= 2\pi \times$ frequency) p and let $\triangle$ be the change in pulsatance of the incoming wave sufficient to cause the power absorbed to drop ten decibels (*i.e.*, to cause $\hat{\imath}^2$ to be reduced in the ratio 1/10). Then $\triangle$ is a convenient measure of the selectivity of the circuit.

We have

$$10 = \frac{R^2 + (2\triangle L)^2}{R^2}$$

$$\text{Therefore } \triangle = \frac{3R}{2L} \quad (3)$$

4. Response to a Modulated Wave.

We are now in a position to consider the response of the circuit to a modulated wave. Suppose the induced e.m.f. is of the form $\hat{e}\cos\mu t\cos pt$. Where μ is the pulsatance of modulation and is small compared with p. Now

$$\hat{e}\cos\mu t\cos pt \equiv \frac{\hat{e}}{2}\cos(p+\mu)t + \frac{\hat{e}}{2}\cos(p-\mu)t$$

$$\text{And hence } i = \frac{\hat{e}}{2}\left[\frac{\cos\{(p+\mu)t - \phi_1\}}{Z_1} + \frac{\cos\{(p-\mu)t - \phi_2\}}{Z_2}\right]$$

Where $Z_1 = Z_2 = \sqrt{R^2 + (2\mu L)^2}$

and $\tan\phi_1 = \dfrac{2\mu L}{R}$

and $\tan\phi_2 = -\dfrac{2\mu L}{R}$

Thus the expression for i simplifies down to

$$i = \frac{\hat{e}}{Z_1}\cos(\mu t - \phi_1)\cos pt \quad \ldots \ldots \quad (4)$$

Hence

$$\hat{\imath}^2 = \frac{\hat{e}^2}{Z_1^2} = \frac{\hat{e}^2}{R^2 + (2\mu L)^2}$$

$n =$ ..	50	100	200	500	700	1,000	2,000	3,000	5,000	7,000	10,000
$P =$ ..	0	0	0	−0.10	−0.19	−0.37	−1.33	−2.57	−5.12	−7.33	−10

If we take the power absorbed at a very low frequency of modulation as the zero decibel level, we have the level at any pulsatance μ given by

* MS. received by the Editor, March, 1930.

$$P = 10 \log_{10}\left\{\frac{R^2}{R^2 + (2\mu L)^2}\right\} \quad .. (5)$$

Which combined with equation (3) gives the equation of the response curve

$$P = 10 \log_{10}\left(\frac{\triangle^2}{\triangle^2 + 9\mu^2}\right) \quad .. (6)$$

It will be noticed that since $\triangle$ and μ are " pulsatances " it is possible to replace them by " frequencies " in the above fraction since the factor $4\pi^2$ divides out.

As was pointed out in a recent Editorial (Vol. VII, No. 78) the induced e.m.f. is usually of the form $(A + \hat{e}\cos\mu t)\ \cos pt$ when a simple tone is being broadcast. However, the term $A\cos pt$ only gives a term $\frac{A}{R}\cos pt$ in the expression for i and since this does not enter into consideration after rectification it is neglected in the above analysis.

5. Example.

Take a circuit tuned to a wavelength of 300 metres and having a loss of 10 decibels for a difference of 10 kilo-cycles in the frequency of the incoming wave. Then the equation of the response curve is

$$P = 10 \log_{10}\left(\frac{10^8}{10^8 + 9n^2}\right)$$

This clearly shows the dropping off of the higher modulation frequencies. (Fig. 1.)

Book Reviews.

Rundfunk-Schaltungstechnik.

By Manfred von Ardenne.

Pp. 118, with 149 figs. Rothgiesser & Diesing, Berlin. R.M. 4.50.

The author has recently published two books, one on the physical foundations of wireless reception and the other, reviewed last month, on the technical development of the subject. The present volume is stated to be the third and final volume of the set. It deals with the various elements which enter into a receiving set and the numerous ways in which these elements can be connected up to obtain the best results. It replaces a book on the same subject published in 1924. The first 90 pages deal with the separate elements and the remainder with complete diagrams of connections of typical sets. Diagrams are given of the various methods of connecting detectors, amplifiers, volume controls, loud speakers, reaction coils and condensers, smoothing devices, etc., etc. The book is entirely non-mathematical and the descriptions are brief. With regard to the relative merits of anode bend and grid rectification, the author says that " the grid rectifier is more sensitive to weak signals and suited therefore to single valve sets or those intended to give head-phone reception of very distant stations. They can be completely blocked, however, by very strong signals or atmospherics and distortion occurs with large amplitudes. Anode rectification, on the other hand, gives linear reception with large amplitudes and is therefore free from distortion on loud signals. It is therefore very suitable after large high-frequency amplification and is increasingly employed in modern apparatus." This is not in accordance with recent articles on the subject. Fig. 39, which illustrates the grid rectification methods, contains a rather misleading misprint, *viz.*, ohne (without) instead of oder (or) and we notice that on the same page the author talks of a small leak when he means a small leakage resistance—a very different matter. Fig. 104 shows what is called a push-pull electrostatic loud speaker, the earthed diaphragm having insulated inductors on both sides of it connected across a choke in the anode circuit. When no signal is being received the pulls on the front and back of the diaphragm are balanced, but when a signal is received it is only the potential of the front plate which varies, that of the back plate remaining constant. This would be more correctly described as a statically balanced loud speaker. To anyone with a knowledge of the language the book can be recommended as giving a non-mathematical review of the subject. G. W. O. H.

Abacs Dealing with Complex Numbers.

By Lucien Abélès.

Revue Générale de l'Électricité, 28, 1930. Pp. 515–526.

In obtaining values of cos, sin, cosh, sinh of a complex number $x + iy$ from tables a double interpolation is necessary, which makes the operation troublesome. The charts published by Professor Hennelly simplify matters by substituting a graphical interpolation, but the mental effort is still considerable. M. Abélès has now succeeded in producing abacs in which each quantity is referred to its own continuous engraved scale and the answer is given by a single setting of a ruler. Owing to the range required for x and y a number of abacs are required, and an index abac is given so that the appropriate chart can readily be found. The abacs given in the paper are on too small a scale to be useful, and it is to be hoped that they will be produced on large sheets for general use. R.T.B.

Condenser Tissues.

Messrs. Robert Fletcher & Son, Ltd., of Stoneclough, near Manchester, have sent us an interesting booklet entitled *Electrical Condenser Tissues and Insulating Papers*, which gives a summary of their researches into the dielectric strength of various condenser tissues and their chemical properties, together with useful tables and data concerning insulating papers.

The Physical Society's Exhibition.

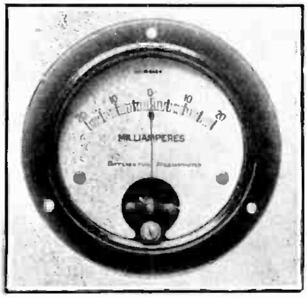
Matters of Wireless and Laboratory Interest.

THE Twenty-first Annual Exhibition of the Physical Society and the Optical Society was held this year at the Imperial College, South Kensington, on 6th, 7th and 8th January. The Exhibition maintained its usual high level of interest in showing progress of instrument development and design, and in measurement technique generally, and in these respects was—as it has now been for some time—a most useful display for those concerned with work in experimental wireless and allied subjects.

Electrical Measuring Instruments.

The Exhibition maintained its usual function in offering a particularly good occasion for a review of the year's tendencies in electrical measuring instruments. Meters of all kinds and for every variety of purpose were shown, but, as on former occasions, we are compelled to restrict review to those of particular radio or laboratory interest.

ELLIOTT BROS. had a wide range of instruments covering power applications and radio uses. Amongst the latter class their portable moving-coil galvanometers were interesting features, as were also their differential milliammeters, with two separate coils giving differentially balanced circuits. Their Type 650B Radio Test Set was a combined voltmeter—milliammeter with ranges of 3, 15 and 150 v. and of 7.5, 75 and 750 mA., full scale. Another feature of radio interest was this company's thermo-junctions, which are now well known.



Elliott differential moving coil milliammeter.

The display of FERRANTI, LTD., was concerned chiefly with measuring instruments. The small radio meters were shown in a wide range of movements, *e.g.*, the ordinary moving-coil, thermo-junction, rectifier and moving-iron. The latest addition is that of electrostatic voltmeters. Sloping desk-stands are now also available for these meters, rendering them of useful portable form in the laboratory.

New features at the stand of EVERETT EDGCUMBE, LTD., were their "Minisquare" a.c. and d.c. ammeters and voltmeters, convenient for either portable or panel use, and available in a very full range of scale values and types. For a.c. voltages, instruments of rectifier type are included, as well as electrostatic voltmeters up to 3,000 v., full scale.

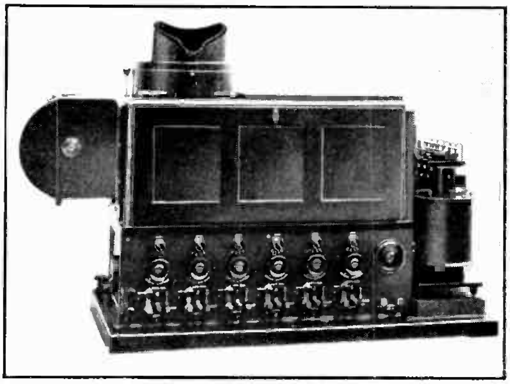
ERNEST TURNER, LTD., besides portable standard d.c. testing instruments and larger instruments of the switchboard type, showed an extensive range of 3½-in. and 2½-in. scale instruments, available for d.c. and for a.c. with thermo couples or with metal rectifiers. A new addition was a direct-reading double-range ohmmeter, using a d.c. movement in conjunction with a battery for the direct reading of resistances.

A Cirscale workshop ohmmeter on this principle was also a new addition to the Cirscale instruments of the RECORD ELECTRICAL CO., along with a new type of constant-pressure ohmmeter up to 2,000 megohms.

Several interesting recording-type instruments of Italian origin were displayed by O. E. MALINVERNO. These included graphic meters for various power and other requirements, and a recording micro-ammeter of 200 mA., full scale. Results obtained with this instrument were shown in the form of fading curves of a distant broadcast station, lent by the Radio Research Board.

Amongst other measuring gear the CAMBRIDGE INST. CO., LTD., showed a new and improved form of thermo-junction, some of sensitivity such as to give full scale deflection on a Unipivot L or Versatile instrument for a current of 1 mA. The Versatile instrument was also shown with its extensive range of multiplying attachments in a carrying-case for easy transport.

THE WESTON ELECTRICAL INSTRUMENT CO. had a typical display of instruments, including their Laboratory Standards, Standard Portable types, and a very extensive display of switchboard and portable instruments, down to a small radio-panel meter of 2in. diameter. Of particular radio interest were their Valve Checker (Model 533) and Radio Set Tester (Model 547), while new additions to their products were to be found in the form of rectifier instruments, and in ohmmeters and combined volt-ohmmeters, the latter (Model 566) having four volt-ranges up to 600 v. (at 1,000 ohms per volt) and resistance ranges of 0–10,000 and 0–100,000 ohms, direct reading.



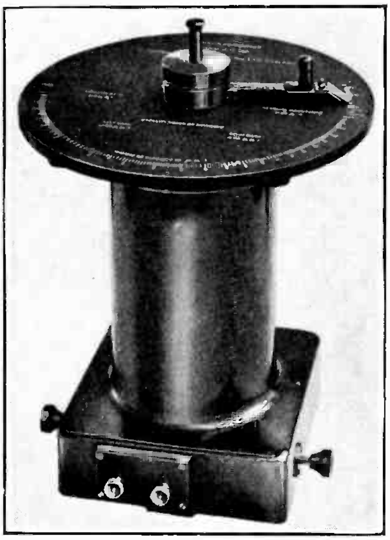
Cambridge Duddell oscillograph.

A special display of rectifier instruments was

shown by the WESTINGHOUSE Co., including instruments of this type made by several firms, *e.g.*, Everett Edgcumbe, Ernest Turner and the Cambridge Instrument Co., using Westinghouse Rectifiers.

Laboratory Equipment.

Amongst new items in this category the CAMBRIDGE INST. Co. showed a six-element Duddell Oscillograph, generally similar in principle to their well-known three-element instrument, but with the optical and illuminating arrangements modified to



Cambridge Moullin condenser.

work the six vibrators. The Moullin variable condenser, described in our last issue, was another new product. The Campbell Frequency Meter was shown this year in a new long-range form up to 12 kc/s., and was demonstrated in operation with a beat-frequency generator designed by Dr. W. W. Dye.

GAMBRELL BROS. had a good display of laboratory and testing equipment. A useful type of condenser bridge was shown, for the rapid comparison of ganged variable condensers, giving the difference of capacity throughout the scale and also the deviation from normal at minimum and maximum settings. Standard fixed condensers, a new standard variable condenser and the McLachlan modulated C.W. wavemeter were also on view. Bridge components and accessories included a valve source of 300–2,000 c/s., balanced and screened bridge transformers and screened boxes of non-reactive resistances. Other laboratory items included a range of very sensitive galvanometers, standard Wheatstone bridges, potentiometers, etc.

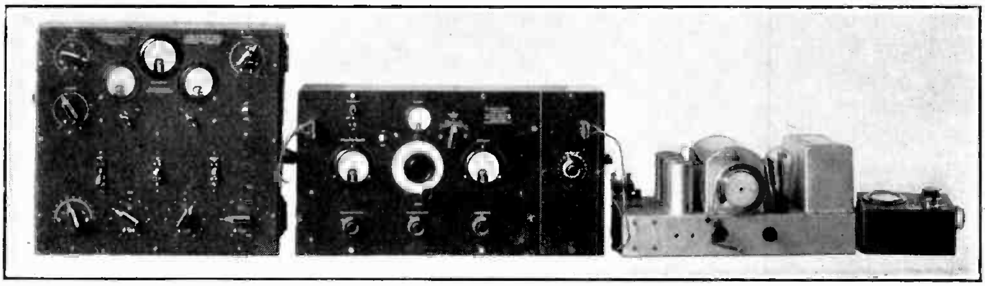
At the stand of EVERSHED, VIGNOLES, LTD., a new item of interest was an insulation and capacity meter for testing condensers of wireless and telephone type, reading up to 4,000 meghoms and 11.5 microfarads.

In addition to the measuring instruments already mentioned, ELLIOTT BROS. showed new forms of vibrating telegraph relay and a new relay test-set, while CROMPTON PARKINSON, LTD., showed their standard potentiometer equipment, Wheatstone bridges, etc.

Amongst apparatus of laboratory interest, the DUBILIER CONDENSER Co., LTD., included adjustable standard condensers and wavemeters of several patterns.

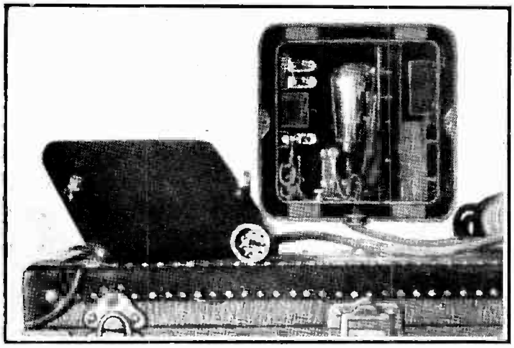
H. W. SULLIVAN, LTD., showed new Short Wave Precision Sub-standard Wavemeters of 10 to 100 M., and a new type of heterodyne wavemeter using a novel method of discrimination between fundamental and harmonic heterodyning. Other new products were a general purposes Variable Air-Condenser, a Low Tension Schering Bridge for power-factor and permittivity tests and a portable capacity test set of wide range (0.00005 to 1 μF. on a single scale). Other items of laboratory gear included the Sullivan Griffiths' variable air condenser on the series-gap principle, the Sullivan Griffiths' Generating Wavemeter, the Standard Miltivibrator Wavemeter and accessories, and the Lucas-Sullivan Quartz Crystal Standard, and the complete Frequency-standardising apparatus using this scheme.

Newcomers to the Exhibition were CLAUDE LYONS, LTD., who are well-known as British agents for several American makers of high repute. Chief amongst their exhibits were products of the General Radio Co., of Cambridge, Mass., who supply a very extensive range of apparatus for wireless test and measurement. One of the most important items



Receiver testing equipment (*Claude Lyons, Ltd.*).

was apparatus for the measurement of sensitivity, selectivity and fidelity of receivers, comprising l.f. oscillator, standard signal generator, standard output meter, etc. Other oscillators shown included the



Condenser microphone (Claude Lyons, Ltd.).

G.R.C. beat-frequency oscillator and maintained tuning fork oscillator. Wavemeters and variable condensers were also on view, along with the G.R.C.'s decade resistance boxes and other components. Amongst other items at this stand should also be mentioned the Jenkins & Adair condenser microphone and control panel, shown for the first time in this country.

H. TINSLEY & Co. had their customary extensive display of laboratory gear, including potentiometers, bridges, tuning forks and stroboscopic apparatus, non-inductive resistance-boxes, wavemeters, non-temperature mica condensers, etc.

Besides the rectifier instruments already mentioned, the WESTINGHOUSE Co. had a range of exhibits intended to show some of the less-known uses of the metal rectifier. These included applications in connection with absorbing energy from inductive discharges on breaking a circuit, and an application of this principle to automatic telephone practice for the maintenance of relays by delay of release. Another application shown was the copper-oxide photoelectric cell.

The display of MARCONI'S W. T. Co., LTD., was devoted largely to measurement and laboratory apparatus. Interesting items were a screened capacity bridge, an impedance bridge and a standard variable condenser for use in conjunction with either of these bridges. A transmission-measuring set shown for the first time is designed on portable lines for the measurement of gains or losses (in decibels) in lines, filters, amplifiers, etc., over a wide range of levels.

The display of MUIRHEAD & Co. included several items of interest in experiment and measurement. Amongst these was a universal bridge on the Wien scheme for resistance, inductance and capacity measurement, and various accessories in the way of condensers, inductances and non-reactive decade resistances.

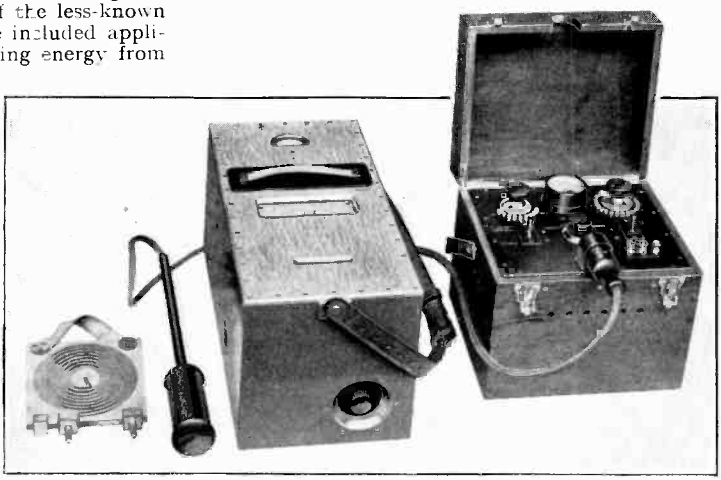
Wireless Apparatus, Accessories, etc.

The stand of the MARCONIPHONE Co. was devoted chiefly to matters of broadcast interest. The chief exhibit was their Model 560, an a.c. mains console-type receiver of high quality, incorporating their new permanent-magnet moving-coil speaker. The new two-valve models shown at the last Radio Exhibition were also on view, along with other five-, four-, and three-valve receivers, and the company's moving-coil and other speakers. An extensive range of receiving valves was also shown, including new two-volt models.

A similar range of receiving valves was displayed by the M. O. VALVE Co., who also showed larger valves of the transmitting class, including cooled-anode valves, with demonstrations of manufacturing processes.

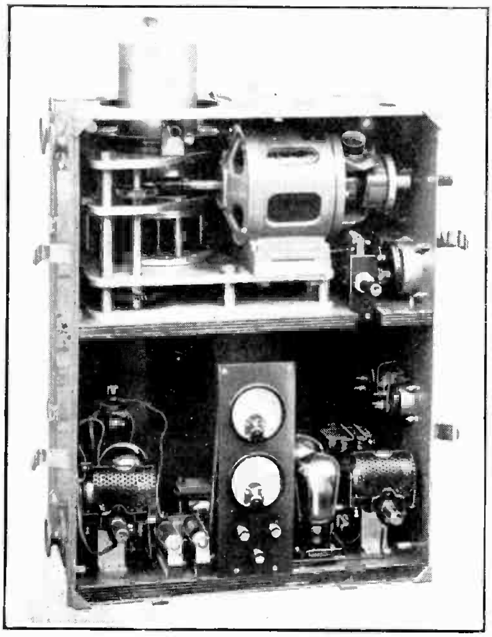
THE MULLARD WIRELESS SERVICE Co. had an exhibit of their valves of all classes, including indirectly heated cathode valves for mains operation and large valves of the transmitting rectifying and modulating types. For several years this firm has had an experiment showing some phase of valve operation. This year one demonstration dissected the currents and voltages present in rectifiers and eliminators, while another experiment was designed to show the setting up of parasitic h.f. oscillations as transients in power amplifiers.

THE DUBILIER CONDENSER Co. had a number of exhibits of radio interest, including two-valve and three-valve all-mains receivers, as well as their radio-gramophones shown at the last Olympia Exhibition. "Auto-dial" apparatus, demonstrated for the first time, is a new appliance for the remote-control tuning of a receiver. Electrolytic condensers up to 200 volts (working) were a



10 *to* 100 *metre Marconi precision wavemeter.*

new feature, while increasing attention was paid to high-voltage condensers, paper and mica, for smoothing high-voltage rectifiers, as in power amplifiers, etc.



Marconi portable picture transmitter.

In addition to the laboratory apparatus mentioned above, the Marconi Co. had several exhibits of commercial interest. Amongst these was Type D.F.G.5A. short-wave d.f. set, utilising the Adcock system of spaced aerials with shielded horizontal limbs, portable picture apparatus for the transmission and reception of rough pictures, maps, sketches and printed matter, and a crystal-control drive-unit for the frequency stabilisation of broadcasting transmitters on waves between 200 and 250 metres.

The Edison-Swan Co., Ltd., had a display of transmitting rectifying and amplifying valves of the larger class by the Ediswan Co., as well as the full range of B.T.H. Mazda valves for reception purposes, this range including the new A.C. Pentode. The newest form of Rice-Kellogg loud speaker with permanent magnet was also on view from the B.T.H. Company, along with accumulators and primary batteries from the Ediswan Co.

Philips Lamps, Ltd., had a display chiefly of X-Ray equipment but an item of acoustic interest was their Type 2720 Amplifier of total 100 watt rating, for talking picture work, and a new photo-electric cell.

Other items of allied interest were :—

Isenthal & Co., rheostats and resistances, photoelectric equipment, mercury switches and relays.

British Electric Resistance Co., woven asbestos resistance nets, bands, etc., for various loading, rheostats, vitreous enamelled units of embedded type, and high-resistance cord.

Bakelite, Ltd., moulding materials and products.

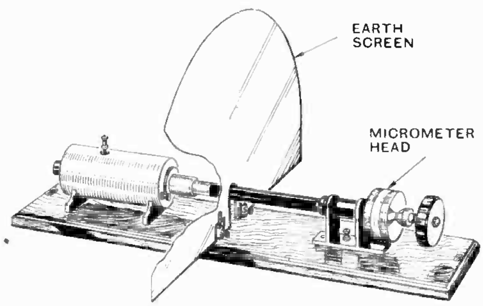
Ebonestos Insulators, Ltd., moulding materials and products.

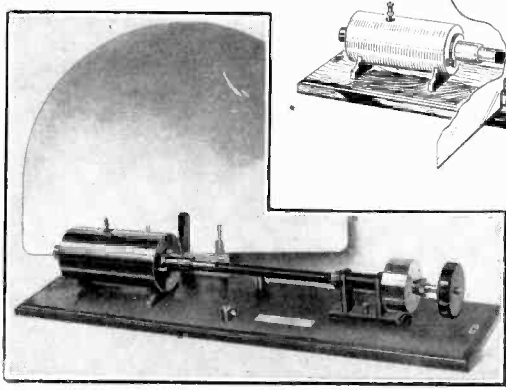
Research and Experimental Section.

As has mostly been the case since this section was started a few years ago, a considerable number of exhibits were of wireless and kindred interest. The main items were from the research establishments of some of the larger commercial firms—*e.g.*, B.T.H., G.E.C., H.M.V.—and from the Wireless Division of the N.P.L.

The B.T.H. (Engineering Laboratory) had apparatus for the analysis of noise or other complex sound, giving the frequency and intensity of the various components. Another interesting demonstration was that of a photoelectric cell working in conjunction with a mercury-vapour three-electrode valve (thyratron), while the mercury-vapour principle was also shown in use on a diode rectifier equipment giving a rated output of 12 amps. at 250 volts. An experiment of wireless interest was that illustrating the phase-change in tuned circuits as the resonance point is passed through.

Amongst wireless items at the stand of the





G.E.C. standard variable condenser. Max. cap. change 0.1 mmfd. Scale reads direct to 0.0001 mmfd. 1 cm. on drum scale corresponds to change of 0.0002 mmfd.

Photo Copyright G.E.C.

G.E.C. Research Laboratories was apparatus for obtaining a range of standard multiples from a tuning-fork of 1,000 c/s, giving multiples of this frequency up to 1 megacycle per second. Other items included a long-range standard variable

condenser, an improved form of condenser-microphone, and loading coils for telephone cables using compressed-powder cores of nickel-iron alloy.

THE GRAMOPHONE Co.'s stand was largely concerned with photoelectric cells and their application to sound reproduction and television. A new type of cæsium cell was shown operating a relay without any amplification. A demonstration of projected television was also given, using a cinema film and breaking up the image into five portions which were transmitted by line and recombined into one projected picture. A demonstration of wireless interest was apparatus for the testing of a broadcast receiver, a Marconiphone 560 chassis being shown under test to ensure that it was up to standard performance.

The NATIONAL PHYSICAL LABORATORY stand contained several exhibits from the Wireless Division, these including :—

(1) Apparatus for telephony transmission and reception on 1½ metres.

(2) Single Loop D.F. Set for 4 to 10 metres.

(3) Model of a Rotating Loop Beacon Transmitter (*e.g.*, as at Orfordness), working on wavelengths between 5 and 20 metres.

(4) Automatic Apparatus for Recording Bearings from a Rotating Loop Beacon Transmitter.

(5) Applications of the Double-Beat Method of Frequency Adjustment.

(6) Demonstration of the Reception of a Modulated Radio-Frequency Wave, showing the Existence of Side Bands.

A new Department to the Exhibition was the P.O. Engineering Research Station (Dollis Hill), which showed a testing set for the rapid check of telephone transmitters and receivers in bulk at contractor's works and a generator for the production of low-frequency currents, deriving square-topped waves of 5 to 100 c/s from a Bandot distributor and correcting them to sinusoidal shape by filter units of different value.

Other exhibits of allied interest were :—

SUPRA ELECTRA MOTORS, LTD., new universal-type motors of fractional horse-power, and direct-drive motors for gramophone.

MR. A. M. CODD, primary cells using electrolyte of ammonium persulphate.

MR. R. W. CORKLING, apparatus for comparative test of light sources, photo cells, amplifiers, etc., in television.

Books Received.

MODERN RADIO COMMUNICATION (3rd Edition). By J. H. Reyner, B.Sc., A.C.G.I., A.M.I.E.E., with a foreword by Prof. G. W. O. Howe.

A textbook on the theory and practice of Radio Communication, covering the syllabus of the City and Guilds Examination and suitable for candidates for the P.M.G. certificate. Pp. 260 + xi, with 121 diagrams and illustrations. Published by Sir Isaac Pitman & Sons, Ltd., London. Price 5s. net.

RADIOACTIVITY AND RADIOACTIVE SUBSTANCES (3rd Edition). By J. Chadwick, M.Sc., Ph.D., with a foreword by Sir Ernest Rutherford.

An introduction to the study of radioactive substances and their radiations, the nature of radioactivity, and the bearing of radioactive transformations on the structure of the atom. Pp. 116 + xii, with 33 diagrams. Published by Sir Isaac Pitman & Sons, Ltd., London. Price 2s. 6d. net.

RADIO-KURZWELLEN UND IHRE EIGENSCHAFTEN. By Franz Anderle.

A text-book on the nature and characteristics of short-waves, with chapters on reflectors, aerials, crystal control, and other kindred subjects. Pp. 122 with 160 diagrams and illustrations, and three maps. Published by Franz Deuticke, Vienna and Leipzig. Price M.6 in paper cover, or M.8.40 in cloth.

RUNDFUNK JAHRBUCH 1931.

The year book of the Reichs-Rundfunk Gesellschaft, relating the progress and performance of the various broadcasting organisations in Germany, with articles on technical matters, events of the past year, and numerous other features. Pp. 417, with 248 illustrations. Published by Union Deutsche Verlagsgesellschaft, Berlin.

A RADIO BEACON AND RECEIVING SYSTEM FOR BLIND LANDING OF AIRCRAFT. By H. Diamond and F. W. Dunmore (Research Paper No. 238, reprinted from the Bureau of Standards Journal of Research, October, 1930).

Describing the systems used in American airports for the guiding of aircraft under conditions of no visibility, and the use of the vibrating reed course indicator, the runway localising beacon, boundary marker beacon, and landing beam. Pp. 34, with 35 illustrations and diagrams. Issued by the Bureau of Standards, Washington, D.C., U.S.A. Price 25 cents.

DIE ELEKTRISCHE SCHALLPLATTEN-WIEDERGABE (Electrical Record Reproduction). By Manfred von Ardenne.

With descriptions and illustrations of various gramophone pick-ups and other apparatus connected with sound reproduction. Pp. 80, with 69 illustrations and diagrams. Published by Rothgiesser und Diesing, A.G., Berlin. Price RM 1.70.

DEMONSTRATIONS-EXPERIMENTE MIT KURZWELLIGEN UND ULTRAKURZWELLIGEN SCHWINGUNGSERZEUGERN. By W. Möller.

A brief description of laboratory experiments with short-waves and ultra-short waves and description of the apparatus used. Pp. 48, with 41 illustrations and diagrams. Published by Rothgiesser & Diesing, A.G., Berlin. Price RM.1.

PHOTO-ELECTRIC CELLS AND THEIR APPLICATION,

A discussion at a Joint Meeting of the Physical and Optical Societies, including the early history. theory, standardisation, manufacture, application and scientific study of photo-electric cells. Pp. 236, with numerous diagrams and illustrations. Published by the Physical and Optical Societies, London. Price, 12s. 6d.

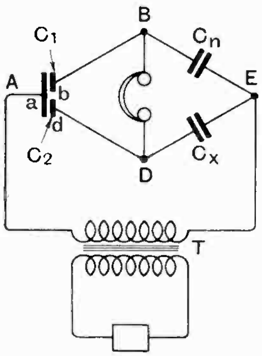
Correspondence.

Letters of interest to experimenters are always welcome. In publishing such communications the Editors do not necessarily endorse any technical or general statements which they may contain.

A Simple Capacity Test Set.

To the Editor, E.W. & W.E.

SIR,—I notice in your esteemed review, issue January, 1931, an article entitled "A Simple Capacity Test Set," by W. H. F. Griffiths, F.Inst.P., A.M.I.E.E.



If I have well understood this article, the apparatus described corresponds to the accompanying diagram of connections. Curiously enough, I published in the *Bulletin de la Sté Belge des Electriciens*, June, 1925, an article describing a similar arrangement. The apparatus in question was patented at the time in the name of the Société Anonyme Internationale de Télégraphie sans Fil, for whose requirements it was specially developed.

I trust that the above information will be of some interest.

S. DIVOIRE.
Société Anonyme Internationale de Télégraphie sans Fil.

Brussels.

To the Editor, E.W. & W.E.

SIR,—I am extremely interested to learn that a capacity test set similar to that I described in the January issue, was described by M. Divoire as early as 1925, and I have to express my thanks to him for drawing my attention to this fact. I much regret that no reference was made to M. Divoire's article as the scheme was thought original, and is so, as far as is known, in this country at any rate.

A further development of the idea which may interest M. Divoire is the use, for ratio arms, of two variable condensers "ganged" together, in a manner now employed extensively in radio sets, and matched for capacity. Moreover, the variable condensers are of sufficiently uniform production to permit the use of a stereotyped scale calibration which is common to all instruments. The uniformity of the variable condensers is judged by the ratio of the maximum capacity of one to the minimum of the other, the mean of the two ratios thus obtained for a pair of ganged condensers being brought within specified limits, if necessary, by a minute adjustment of the *minima* of the condensers by auxiliary capacities.

W. H. F. GRIFFITHS.

London, S.E.1.

On the Definition of Selectivity.

To the Editor, E.W. & W.E.

SIR,—A Good Definition of Selectivity must be :—

(1) Theoretically satisfactory, that is to say it must be based on theoretically important quantities, on characteristic physical constants ; and it must lend itself to the convenient calculation of the essential properties of the system concerned.

(2) Practically adequate, that is to say it must conveniently represent the selectivities of existing apparatus and must be capable of extension to the range of future developments in selectivity.

(3) As simple as possible, so that its use may become general in all the classes concerned.

Here are some reflections on these three points.

(1) *Theoretically*, "selection" consists in separating out the signals from the midst of interference of various sorts, whether due to other stations or to atmospherics, spark noises, etc., by means of the difference in frequencies.

The signals are characterised by a carrier frequency, together with a modulation or a manipulation—*i.e.*, bands of side-frequencies. The carrier frequency may be anywhere in a wide range, from a few kilocycles to some millions of kilocycles. On the other hand, the band widths are clearly defined for each type of signal : about 2×100 for telegraphy, $2 \times 2{,}500$ for commercial telephony, and $2 \times 5{,}000$ to $2 \times 8{,}000$ for the "artistic" telephony of Broadcasting.

The sources of interference can often be defined in an analogous manner. In particular, in the Broadcasting zone international regulations prescribe systematic intervals, in the multiples of 10 kc., between the frequencies of the various stations.

Thus in both cases it is the *absolute* width of the band which is of importance. It seems, therefore, logical to make use of this absolute width ; and without denying the interest in sometimes considering the *relative* intervals, I agree with Mr. Biedermann* : it is the *absolute* frequency-interval which ought to be used in the definition of selectivity—*i.e.*, $d\omega$ and not $d\omega/\omega$.

Another point : it has been shown, and it is generally agreed, that the "ideal" selectivity is represented by a curve of rectangular shape ; the "passing" band (formed by the signals) passing almost freely—and directly after, the attenuation being enormous, to stop all kinds of interference. Now chains of resonators do not get anywhere near to this ideal shape of curve ; nevertheless, systematic detuning and an increase in the number of circuits in series have an improving effect. And, on the other hand, the employment of filters and similar combinations tends to come into general use. There is no doubt but that, in the future, inventors and constructors will find and develop better and better methods of obtaining almost

* *E.W. & W.E.*, 1929, Vol. VI., pp. 552 and 622.

ideal selectivities. This being so, I cannot consider any definition satisfactory which rejects *a priori*, the case of filters. To do this is to ignore exactly what constitutes the merit, the excellence, the originality of a circuit. Whatever definition is adopted, therefore, must take into account *how nearly the system in question approaches the ideal selectivity*.

(2) *Practically*, the selectivities met with in existing apparatus obviously vary very greatly, according to their design, the way they are used, and above all the band of frequencies in which they work. According to theory, the higher the frequency on which the selectivity operates, the smaller are the time-constants of the circuits and the flatter the selectivity curve.

I myself have had occasion to plot experimentally a good many curves, and I have also carefully collected practically all those which have appeared in current literature. A combination of all these gives a good idea of average selectivity, as is shown roughly in Fig. 1.

Here the abscissæ represent frequency intervals in kilocycles (per second); the ordinates represent the decrease in strength with respect to the resonance strength, on a logarithmic scale. The graduations are in decibels (20 decibels, a weakening of 1 : 10; 40 decibels, 1 : 100; 60 decibels, 1 : 1,000, and so on).

Three zones can be seen, corresponding respectively to the selectivities at the very high frequencies (above 6,000 kc.), the Broadcast frequencies (some hundreds of kilocycles), and lastly at the intermediate and audible frequencies.

Naturally, in the case of a frequency-change receiver the selectivity is of the order of magnitude of that obtained at the lowest frequency.

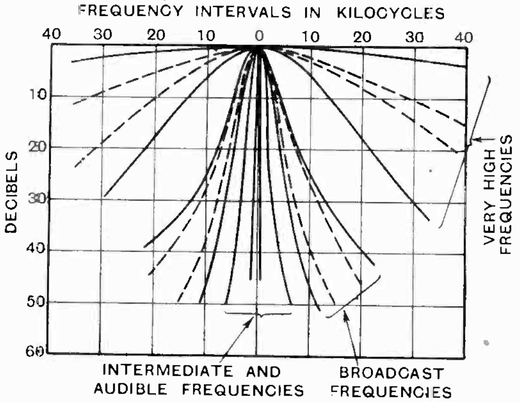


Fig. 1.—*Types of Selectivity Curves plotted experimentally from chains of Resonators.*

Fig. 2 gives some examples of selectivities obtained by filters; it is only for illustrative purposes, since there is no theoretical limit to the selectivity of filters. At acoustic frequencies the curve would, on our scale, be merged in the ordinate axis.

Let us then consider the variety of curves given in these two diagrams: is it possible to define each one *by a single number*, however carefully chosen this may be? We think *not*; and it is for that reason that we feel unable to approve the definition of Mr. Colebrook* (which means considering only the curvature at the origin) any more than we can

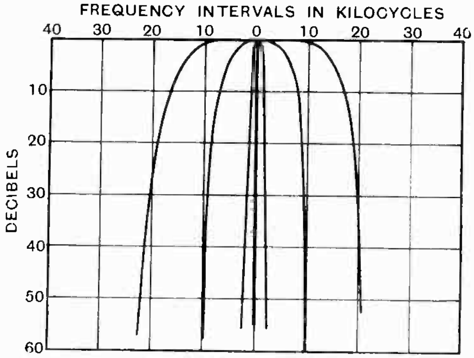


Fig. 2.—*Examples of Selectivity Curves obtained with Filters.*

approve that of Mr. Beatty† (which means considering only the 20-decibel ordinate).

(3) *Simplicity*. The definition involving the second derivative leads to very complicated calculations directly the selective arrangement is at all complex. Moreover, in a graph plotted experimentally this curvature is not at all easy to measure.

Proposed Solution. Selectivity can only be defined by a *curve*, or by giving several points on such a curve.

One may, as proposed by Mr. Biedermann, give the weakening due to the selectivity for certain fixed detuning intervals; but the difficulty is that these intervals would have to be chosen in different frequency bands; they could be less than 1 kc. in the audible frequency bands; in the Broadcast band they would be 10, 25, or 50 kc., for example (see Fig. 1)—or one could give the weakening for a 5 kc. detuning, which would describe not the true selectivity but rather the fidelity of reproduction; while for very high frequencies, one would with advantage go to 100 kc. or more.

On the other hand, a variation of the above would be to give *the frequency-intervals corresponding to fixed degrees of weakening*.

Thus one could take the following degrees of weakening :—

In decibels	10	30	50	80
Ratio of Currents	1/3	1/30	1/300	1/10,000

In this way one would have an absolutely general form applicable to every zone of frequency.

I myself have recently had occasion to appreciate its convenience: the American proposals at the Hague Conference contained a discussion of Selectivity based on tables following this principle. I found it a very easy matter to reconstruct the corresponding curves and to appreciate the results obtained.

To sum up, then, the definition would be as follows :—" If A is the electrical quantity supplied

* See *E.W. & W.E.*, Vol. VI., p. 422.
† See *E.W. & W.E.*, Vol. VII., p. 361.

(*e.g.*, applied e.m.f.), and B is the electrical quantity utilised (*e.g.*, output current, or potential across the terminals of a certain instrument), in the selective system: then the ration B/A is a function of the frequency; in particular, it is a maximum for a certain resonance frequency f_r, or in a certain pass-band $f_1 - f_2$. In the latter case the resonance frequency would be taken as the mean, $f_r = \sqrt{f_1 f_2}$. For any other value of frequency, displaced by Δf (so that $f = f_r \pm \Delta f$), the ratio B/A is inferior or equal to this maximum. The quotient of the two values, $S = \frac{(B/A)_{\max}}{(B/A)f}$, represents the Selectivity. Its logarithm, multiplied by 20, expresses it in decibels (it is easy to have a table or an abac to get rid of all calculation). For any system, the values of Δf would be given corresponding to degrees of weakening fixed in advance, such as 10, 30, 50, and eventually 80 decibels."

Advantages of this Solution.

(1) It brings into the line of reckoning the absolute intervals of frequency, which are in direct relation to the width of band occupied by the signals or by the interfering stations.

(2) It allows it to be seen how nearly the system in question approaches the "ideal" selector.

(3) It is applicable to all existing systems and to all regions of frequency; it is capable of extension or modification by changing the standard degrees of weakening.

(4) It can be arrived at very conveniently, either by calculation, substituting certain values by trial and error, even in the most complicated cases (filters); or, starting from a graph, by the measurement of a few ordinates.

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Loud Speakers.

To the Editor, E.W. & W.E.

SIR,—I am gratified to find that Mr. Oliver,* in his recent article on loud speakers and their response curves, is in general agreement with the ideas I put forward before the Student's Section of the I.E.E. on Nov. 19, 1929, an Abstract of which Paper is appearing shortly in the I.E.E. Journal.

Since that date, however, continuous study of the principles of transmission has convinced me that Bostwick's criterion for the response of a loud speaker for a particular frequency is the correct one to use for practical purposes, if only for the simple reasons that it is easier to measure and requires no impedance correction when used for the over-all air-to-air response of a complete reproducing system.

Considering a loud speaker from the scientific point of view as a single entity, the figure for the conversion-efficiency (total sound-power-output/electrical-power input) is of primary importance. In use, a loud speaker is the last link in a reproducing-system and has to be supplied with power from an amplifier. Assuming that an output-transformer is used, the maximum linear power-output (for a given alternating voltage on the grid of the last valve) is obtained when feeding into a load-impedance which equals the conjugate of the output-impedance. A correctly designed output-transformer, that is, one with sufficient mutual and minimum leakage inductances, has an output-impedance which is substantially a resistance, depending upon the differential resistance of the valve (often given erroneously by the makers), over its operating pass-band of frequencies. It therefore follows that the maximum power-output is obtained over the maximum frequency-band when the amplifier is terminated by the matching resistance.

If the resistance is exchanged for the impedance of a loud speaker, and the condition of maximum power-output at a particular frequency is not satisfied because the impedance of the loud speaker differs from the matching resistance, then the loss of sound-output due to the reflection-loss is just as important a contribution to the response of the loud speaker as a loss in radiation-efficiency, or a loss in the mechanism, and should not be divorced from these quantities, except for the purpose of analysis.

Bostwick's figure for the response (that is, the ratio of the total sound-power-output to the power given by the amplifier to a terminating impedance, in practice a matching resistance) takes all these response-contributions into account. Acceptance of Bostwick's criterion clarifies the vexed question of matching the constant output-impedance of the amplifier with the variable impedance of a loud speaker. Between a given loud speaker and the output of the amplifier a variable-ratio transformer is interposed and the output-tapping varied until we are most pleased with the reproduction, either on the basis of apparent over-all efficiency or quality. There is nothing more that can be done short of altering the design of the loud speaker.

In measuring the loud speaker response, a constant power-level for every frequency to be applied to the loud speaker may be adjusted in three ways, (1) by switching from the loud speaker to a matching resistance containing a thermo-couple or valve-voltmeter, (2) measuring the alternating voltage on the grid of any valve in the amplifier, or (3) measuring the voltage applied through an input impedance to the input transformer of the amplifier.

Measuring the total sound-power-output by means of polar-diagrams is essential, but it is a weary business. Since it is the total sound-power that is required, Mr. Oliver would no doubt agree with me that a reverberation method, which automatically integrates the total output of sound, has many recommendations. Such a method has recently been developed by Meyer and Just (*Zeits. f. Techn. Phys.*, No. 8, 1929), and remarkable agreement (within 3 decibels) was obtained between efficiencies measured by the reverberation and polar-diagram methods for several different frequencies.

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London, W.1.

* See *E.W. & W.E.*, Vol. VII., p. 653.

Abstracts and References.

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PROPAGATION OF WAVES.

BEITRÄGE ZUR OPTIK ENDLICHER WELLENZÜGE (Contributions to the Theory of Optics of Finite Wave Trains).—D. Elert. (*Ann. der Phys.*, 1930, Series 5, Vol. 7, No. 1, pp. 65–102.)

This paper gives a theoretical discussion of the phenomena of reflection and refraction of infinite and finite linearly polarised wave trains of sudden onset and perpendicular incidence at a plate of isotropic refracting material with plane parallel faces. The reflected wave is formed by secondary radiation from the molecular resonators in the material and so can never coincide exactly with the incident wave; the peculiarities of the resonator are impressed upon it, altering its form. At the instant of onset of the wave train, neither reflection nor refraction occur; the medium behaves as if it were optically void until the molecular resonators are set into forced oscillation. The secondary spherical waves they then emit interfere with one another and with the incident wave to give a process of reflection and refraction; and not until the movement of the resonators has reached its final steady value do the reflected and refracted waves assume the form given by Fresnel's formulæ.

General formulæ are derived for the electric field in front of, within and behind the refracting plate, and these are specialised to the following cases:

(1) An infinite wave train of constant frequency and sudden onset at the plane face of a medium filling a semi-space. Formulæ and diagrams are given for the reflected wave in two cases where the phases of the incident waves differ by 90° and for the refracted wave. In the latter there are first of all two kinds of "preliminary tremor" ["Vorläufer"]; the first has a velocity c equal to that of light in vacuo and the second a velocity $\frac{c}{\sqrt{\epsilon}}$, where ϵ is the dielectric constant. The main signal arrives subsequently.

(2) An infinite wave train of the same type as in (1), but incident on a plate of finite thickness. Results similar to those of (1) are obtained.

(3) A wave train of finite length: this is regarded as produced by the superposition of two infinite wave trains of the type discussed in (1) and (2), one being of opposite sign to the other and following it after an interval. Figures are also given for this case and for the case when the incident wave has the form

$$E = 0 \text{ for } \left(t - \frac{x}{c}\right) < 0 \text{ and } \left(t - \frac{x}{c}\right) > T,$$

$$E = \text{constant for } 0 < \left(t - \frac{x}{c}\right) < T.$$

The special case of an impulse is also considered.

THE PROPAGATION OF ELECTROMAGNETIC WAVES IN A REFRACTING MEDIUM IN A MAGNETIC FIELD.—D. R. Hartree. (*Proc. Camb. Phil. Soc.*, Jan., 1931, Vol. 27, Part 1, pp. 143–162.)

Author's summary:—The equations of propagation of electromagnetic waves, simple harmonic in time, in an optically anisotropic stratified medium are obtained from the treatment of the refracted wave as the resultant of the incident wave and wavelets scattered by the elements of volume of the medium, and are reduced to a simple form.

The primitive property of the medium, from which the other optical properties are derived, is the scattering tensor, relating the induced dipole moment per unit volume to the applied electric field.

The relation between the dielectric tensor (corresponding to the dielectric constant of an isotropic medium) and the scattering tensor is obtained.

A medium consisting of classical oscillators in an external magnetic field is then considered, the scattering tensor and dielectric tensor are evaluated for such a medium, and finally a formula for the refractive index is obtained.

For an ionised medium the formula differs from that obtained by Goldstein; the difference is due to the inclusion in the present treatment of a term omitted by Goldstein; the significance of this term is discussed, and its inclusion justified.

Taking this term into account makes an important difference to the properties of the medium for long waves; an example is given.

LA HAUTE ATMOSPHÈRE ET L'ÉVOLUTION DES APPLICATIONS DE LA RADIOÉLECTRICITÉ (The Upper Atmosphere and the Evolution of the Applications of Radio-electricity).—G. Ferrié. (*Génie Civil*, 10th Jan., 1931, Vol. 98, pp. 44–45.)

Résumé of a lecture to the Society of Civil Engineers.

SUR LA RÉFLEXION DES ONDES ÉLECTROMAGNÉTIQUES (The Reflection of [ultra-short] Electromagnetic Waves).—C. Gutton and G. Beauvais. (*Comptes Rendus*, 29th Dec., 1930, Vol. 191, pp. 1418–1420.)

A Pierret oscillator for 17 cm. waves was arranged with its aerial lying on the focal line of a cylindro-parabolic mirror, and the resultant parallel beam was directed on to a reflector composed of straight copper wires, all of the same length, spaced by a distance equal to that length, and mounted in rows in one plane by means of cotton stretched across a 1 m. frame. The reflected waves were received on a tuned wire with a thermo-couple at

its mid-point. Five reflectors were made, the wires ranging from 6 to 10 cm. in length.

The 8 cm. resonators were very nearly in resonance and their system reflected the incident beam perfectly when the wires were parallel to the direction of the electric force. For every other direction, only the component of the electric force parallel to the resonators was reflected, the component at right angles being transmitted. Thus the system behaved as a mirror reflecting a ray polarised in the plane parallel to the direction of the resonators. The other reflectors, not in resonance, only reflected a small fraction of the incident energy.

With normal incidence, a system of stationary waves was obtained, and the distances of the nodes and loops from the reflector were measured and compared with those obtained with a zinc-plate mirror 1 m. square. In this way the phase change at reflection by the resonators was compared with that produced by reflection at a metal surface. Expressed in fractions of a wavelength, the differences in distance ranged from + 0.127 for the 6 cm. resonators, through a minimum of − 0.038 for the 8 cm., to − 0.168 for the 10 cm. resonators; representing a phase advance for the resonators with a period shorter, and a phase retardation for those with a period longer, than that of the incident waves. The observed phase-changes corresponded to the displacement of current with respect to e.m.f., this displacement reversing at the passage through resonance.

From the change of phase at reflection it was possible to deduce the damping of the free oscillations of the resonators by the equation $\tan \phi = \frac{\Omega - \omega}{a}$ where a is the damping and Ω and ω are the angular frequencies of the incident oscillations and the free resonator oscillations, the amount of de-tuning being taken as small. The value for a came out at 0.14×10^{10}, as compared with Sonoda's result (1930 Abstracts, p. 570) of 0.123×10^{10}.

Sur la Constante diélectrique et la Conductibilité des Gaz ionisés (The Dielectric Constant and Conductivity of Ionised Gases).—Th. V. Jonescu and C. Mihul. (*Comptes Rendus*, 29th Dec., 1930, Vol. 191, pp. 1436–1438.)

Experiments on the dielectric constant and conductivity of the dielectric between two condenser plates fixed outside a glass tube evacuated to 0.0004 mg. Hg.; at the far end of the tube is a filament and grid, nearer the condenser plates there is a copper ring, and at the other end an aluminium anode; the filament and grid have a p.d. of 100 to 250 v., and an accelerating potential variable from 400 to 2800 v. is applied between filament and ring. The ring and the anode are connected through a milliammeter which reads the current in the portion of the tube between them.

When ring and plate are at the same potential, it is found that the variation ΔC of the capacity, and the conductivity $\frac{1}{\rho}$ of the dielectric, are both proportional to the intensity of the electronic current. The writers have taken the values obtained under these conditions for different wavelengths, reduced them to correspond to an electronic current of 1 mA., and divided by λ^2. The variation of the values thus obtained, with the length of wave, shows that in the case of air the variation $\frac{\Delta C}{\lambda^2}$ is negative for waves between 2 and 12 m. and then becomes positive. It is independent of accelerating potential between 400 and 2800 v. The wavelength at which it changes its sign is independent of electronic current intensity between 0 and 2 mA.

The conductivity $\frac{1}{\rho\lambda^2}$, which also is proportional to the intensity of ionisation, varies with wavelength in a less simple manner. An accelerating potential of 400 v. gives it two maxima ($\lambda = 2.4$ m. and 6 m.) and a minimum at 3.30 m. For longer waves it quickly decreases and tends towards zero for infinite wavelength. With 1600 v. it remains constant up to 6 m. and then falls quickly towards zero.

Über die Beziehungen zwischen Empfangs-Störungen bei Kurzwellen und den Störungen des magnetischen Feldes der Erde (On the Connection between Short Wave Fading and Disturbances of the Earth's Magnetic Field).—H. Mögel. (*Telefunken-Zeit.*, Dec., 1930, Vol. 11, No. 56, pp. 14–31.)

A paper based on prolonged observations at the Geltow receiving station of the Transradio Company, combined with magnetic records from all over the world. A large number of graphs are given to illustrate the connection between magnetic field variations and both slow and quick fading. The latter type of fading is usually supposed to be entirely unconnected with magnetic variations, since it occurs usually in quiet magnetic conditions; but these observations link it up to a special type of magnetic disturbance, the "bay-disturbance," occurring only on the daylight half of the earth.

The writer concludes that while short-wave fading can be explained without postulating any direct effect from changes in the earth's magnetic field, by the assumption of eddy and "whirl" formations and other processes in the Heaviside layer, nevertheless the magneto-ionic theory shows that the earth's field has an important influence on short-wave propagation. He therefore considers that the following scheme holds good:—

$$\begin{array}{ccc} & \text{Solar disturbances} & \\ & \downarrow & \\ & \text{Changes in the Heaviside layer} & \\ \downarrow & & \downarrow \\ \text{Fading} & \leftarrow & \text{Magnetic disturbances} \end{array}$$

The following practical conclusions are drawn, for the overcoming of fading troubles:—(*a*) During magnetic storms, the horizontal sharpness of focusing of the transmitting aerial system should be diminished so that the more widely separated beam may find its way by less disturbed routes (sometimes the daytime beams from New York to Europe have been almost inaudible at Geltow, whereas a beam directed to S. America was moderately workable). (*b*) Relay transmitters

near the magnetic equator. (*c* and *d*) For prolonged fading such as occurred in 1930, the use of the transition wavelength during the daytime is sometimes useful. But strong slow fading setting in suddenly in the midst of calm conditions, and rapid fading, generally affect the transition wave also; and in that case the only hope is the 10–20 kilometre wave. So although the next few years may see better conditions obtaining, owing to the 11-year sunspot minimum, the bad years will come again and it is therefore essential that long-wave stations and technique should be improved—since there seems at present no chance of doing without them.

SOLAR AND MAGNETIC ACTIVITY AND RADIO TRANSMISSION.—L. W. Austin, E. B. Judson and I. J. Wymore-Shiel. (*Proc. Inst. Rad. Eng.*, Dec., 1930, Vol. 18, pp. 1997–2002.)

Authors' summary:—In this paper curves are shown indicating a connection between the annual averages of sun spot numbers and daylight radio signal strength of Nauen, Germany, as received in Washington from 1915 to 1929. The curves of the monthly averages of sun spots and daylight transatlantic signals for the years 1924–1929 show little evidence of correlation. On the other hand, the correlation between these monthly average signals and terrestrial magnetic activity seems definite. Reception from Monte Grande (Argentina) shows less definite and on the whole inverse correlation with magnetic activity. This indicates that long waves, like the ultra-short, are more influenced by magnetic activity when travelling across the earth's magnetic field than when travelling parallel to it.

WAVE PROPAGATION AT VELOCITIES MUCH LESS THAN THAT OF LIGHT [Experiments with the Electrodeless Discharge at Ultra-high Frequencies].—M. Chenot: G. Ferrié. (*See* abstract under "General Physical Articles.")

SOME EXPERIENCES WITH SHORT-WAVE WIRELESS TELEGRAPHY.—N. H. Edes. (*Proc. Inst. Rad. Eng.*, December, 1930, Vol. 18, pp. 2011–2031.)

A paper based on data obtained in China, as a result of the working of traffic and organised tests between the British military wireless stations during the civil war of 1927–1928; the country covered stretched over 1,200 miles and 17 degrees of latitude.

An analysis is given of the factors that may be expected to determine the transmission phenomena peculiar to any given short-wave channel. It is considered that the wavelength which will give the greatest probability of satisfactory communication is determined by (*a*) the great circle distance, (*b*) the geographical positions of the stations, (*c*) the time of year, and (*d*) the time of day. It is pointed out why the *latitudes* of the stations will be a pertinent factor.

A summary is given of the working experiences and the results of the tests over the various "links." The diurnal and seasonal variations of best wavelength are recorded, and it is shown that the seasonal variations coincide approximately with the equinoxes. Results are combined into a "range—best wavelength diagram" for the belt of latitude lying between 30 and 40 deg. N. It is thought that the curves for daylight would apply closely to any part of the world (provided *both* stations were in daylight) but that those for darkness would need considerable modification for different latitudes. An approximate law for best wavelength in daylight, for summer or winter, is given by $\lambda = 0.046\ (1120 - d)$, where λ is the wavelength in metres and d is the range in miles. The wavelengths used were from about 20 to 60 m., with powers (input to valves) from about 100 to 300 watts.

PROPAGATION MEASUREMENTS ON 200–600 METRE WAVES.—M. Bäumler. (*E.N.T.*, Dec., 1930, Vol. 7, p. 502.)

Summary of the results of the German P.O. observations. The night values varied very much, especially at the greater distances; sometimes reaching the values according to the Hertzian formula neglecting damping. Day values were more uniform and smaller; if it was attempted to represent them as the product of Hertzian values and a damping factor, a damping factor was obtained which decreased with increasing distance: this must be due to the addition of energy from the upper atmosphere.

RADIO BROADCAST TRANSMISSION IN THE NEIGHBOURHOOD OF SYDNEY, N.S.W.—L. S. C. Tippett and W. G. Baker. (*Trans. Inst. of Eng.*, Australia, 1928, Vol. 9, pp. 129–146.)

The absorption of energy is very large towards the N. and very small to the S. To the N. the country is very rocky and wooded, while to the S. the ground slopes down gradually from a height of 400 ft. to sea level, part of the path being over the harbour. The equivalent conductivity of the ground, from theoretical considerations, is given as between 1×10^{-14} and 5×10^{-14} e.m.u. The power radiated by the station is estimated at 4,100 w., or 82 per cent. of the input.

SHORT WAVE FIELD STRENGTH MEASUREMENTS.—G. Leithäuser. (*E.N.T.*, Dec., 1930, Vol. 7, pp. 502–503 and 504.)

With the short wave apparatus used, a sensitivity of 10μv. was attainable. The signal was measured against a local signal; the great difficulty was the complete screening of the local circuit from the receiver, which was successfully accomplished by double screens of copper and aluminium and the use of an artificial metallic earth under the whole apparatus.

FIELD STRENGTH MEASUREMENTS AND THEIR PRACTICAL APPLICATION: CONTOUR CHARTS OF SWEDISH STATIONS.—Lemoine. (*See* under "Stations, Design and Operation.")

ÜBER DIE VORGÄNGE IM ELEKTROMAGNETISCHEN FELDE, DARGESTELLT DURCH DIE KRAFTLINIEN (On the Representation by Lines of Force of the Phenomena in the Electromagnetic Field).—G. Siemens. (*Zeitschr. f. Phys.*, Vol. 66, No. 5/6, pp. 396–413.)

SUR L'EXISTENCE HYPOTHÉTIQUE DANS L'EAU DE RÉSONATEURS DE FRÉQUENCE HERTZIENNE (On the Supposed Existence in Water of Resonators of Hertzian Frequency).—P. Girard and P. Abadie. (*Comptes Rendus*, 22nd Dec., 1930, Vol. 191, pp. 1300–1302.)

Frankenberger found that very carefully distilled water gave none of the strong bands of dispersion and absorption found by Weichmann in the 50–60 cm. wavelength region, but found them, on the other hand, in a weak aqueous solution of $NaHSiO_3$. Romanoff deduced from this the existence of resonators composed of molecules of water grouped round negative $(HSiO_3)$ ions. The present writers, however, find no dispersion bands and no discontinuities in absorption either in water or in Na_2SiO_3 solution, in the same range of wavelengths. They employed Drude's first method (Lecher wires in air and in the liquid), and ϵ was found to lie between 79.4 and 80.1 for water and between 83.9 and 84.8 for the solution. Further, at wavelengths of 35, 28 and 18 cm. they found a constant value for water very close to 80.

They point out that the wavelength at which water dipoles should begin to follow the field oscillations would be 1 cm., according to the Debye relation; therefore it would be between 1 and 18 cm. wavelength that a large increase in dielectric constant might occur.

ZUR THEORIE DER ELEKTRISCHEN HEIZUNG (On the Theory of Electric Heating) [Mathematical Investigation of the Reflection and Refraction of Electro-magnetic Waves at Metallic Surfaces and Calculation of the Energy Absorbed in the Metal].—F. Walter. (*Arch. f. Elektrot.*, 5th Dec., 1930, Vol. 24, No. 5, pp. 574–592.)

SUR LA LUMIÈRE TRANSMISE DANS LE CAS DE RÉFLEXION DITE TOTALE (On the Light Transmitted in So-called "Total Reflection").—A. de Gramont. (*Comptes Rendus*, 5th Jan., 1931, Vol. 192, pp. 40–43.)

An investigation of the fact that whatever the quality of the reflecting surface of the prism may be, total reflection never really occurs, part of the light being transmitted to the outside of the prism.

RECHERCHES EXPÉRIMENTALES SUR LA PROPAGATION D'ONDES AÉRIENNES DANS UN LONG TUYAU CYLINDRIQUE (Experimental Researches on the Propagation of Air Waves in a Long Cylindrical Tube).—Th. Vautier. (*Ann. de Physique*, Nov., 1930, Vol. 14, pp. 263–626 and plates.)

DIFFRACTIVE REFLECTION AND SCATTERING.—Boyle and Lehmann. (*See* under "Acoustics.")

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY.

ON THE QUESTION OF THE CONSTANCY OF THE COSMIC RAYS AND THE RELATION OF THESE RAYS TO METEOROLOGY.—R. A. Millikan. (*Phys. Review*, 1st Dec., 1930, Series 2, Vol. 36, No. 11, pp. 1595–1603.)

Author's abstract:—Mean cosmic-ray intensities have been measured with much precision both at Pasadena, California (latitude 34), and at Churchill, Manitoba (latitude 59), the latter a distance of 730 miles from the North magnetic pole.

(1) The observed equality in these intensities indicates that these rays enter the earth's atmosphere as photons rather than as streams of electrons.

(2) Evidence is presented that the incoming rays are of a uniform intensity in all directions and in all latitudes, the small and apparently erratic fluctuations found by many observers at different stations arising simply from eruptions, waves or ripples which change the thickness of the atmospheric blanket interposed between the source and the observer.

(3) The cosmic ray electroscope thus acquires significance as a meteorological instrument.

(4) The influence of these rays in the maintenance of the earth's charge is considered.

THUNDERSTORMS AND THE PENETRATING RADIATIONS (2).—B. F. J. Schonland. (*Nature*, 27th Dec. 1930, Vol. 27, p. 1013.)

Thunderclouds which seem to have an excess +ve charge elevated above a −ve charge produce much larger reductions in the intensity than the more usual type. This can readily be interpreted if the primary radiation consists of positively charged particles or of ultra-gamma quanta, but it does *not* support the fast beta ray theory. *See* also January Abstracts, p. 34.

DURCHDRINGENDE HÖHENSTRAHLUNG—ULTRA-STRAHLUNG—UND KOSMISCHES GESCHEHEN (The Penetrating Radiation—Cosmic Rays—and Cosmic Processes).—E. Regener. (*E.N.T.* Dec., 1930, Vol. 7, pp. 451–462.)

NOTE ON THE NATURE OF COSMIC RAYS.—P. S. Epstein. (*Proc. Nat. Ac. Sci.*, Oct., 1930, Vol. 16, pp. 658–663.)

Bothe and Kolhörster have found that the ionisation phenomena, by which cosmic rays are measured, are produced by highly penetrating corpuscular rays. To decide whether these rays are the cosmic rays themselves or only a secondary radiation, the writer examines the possibility of electrons of 10^9 v. energy producing results consistent with the observed intensity distribution of cosmic rays on the earth's surface. He shows that owing to the earth's magnetic field such electrons, coming from outside, can strike the earth only in two limited zones around the magnetic poles. "This leaves the following possibilities: (*a*) cosmic rays are electromagnetic waves, (*b*) they are corpuscular rays of a very much higher energy than 10^9 volt (at least 6×10^{10} volt), (*c*) they are not cosmic but have terrestrial origin."

ÜBER SCHWANKUNGEN UND BAROMETEREFFEKT DER KOSMISCHEN ULTRASTRAHLUNG IM MEERESNIVEAU (On Variation and Barometer Effect in Cosmic Ultraradiation at Sea Level).—E. Steinke. (*Zeitschr. f. Phys.*, 14th Aug., 1930, Vol. 64, No. 1-2, pp. 48–63.)

UNTERSUCHUNG ÜBER DIE BEZIEHUNG DER HÖHENSTRAHLUNG ZUR ERDMAGNETISCHEN STÖRUNGEN (Investigation of the Relation of Cosmic Radiation to Terrestrial Magnetic Disturbances).—W. M. H. Schulze. (*Physik. Zeitschr.*, 15th Nov., 1930, Vol. 31, No. 22, pp. 1022–1025.)

DIE ÜBERGANGSEFFEKTE DER KOSMISCHEN ULTRASTRAHLUNG BEI VARIATION DES ABSORPTIONSMEDIUMS (Transition Effects of Cosmic Radiation on Change of Absorbing Medium).—E. Steinke. (*Physik. Zeitschr.*, 15th Nov., 1930, Vol. 31, No. 22, pp. 1019–1022.)

ERGEBNISSE DER ULTRASTRAHLUNGSMESSUNGEN IN NORD-SCHWEDEN (Results of Cosmic Radiation Measurements in North Sweden).—A. Corlin. (*Physik. Zeitschr.*, 1st Dec., 1930, Vol. 31, No. 23, pp. 1065–1071.)

DIE STERNZEITSCHWANKUNGEN DER HÖHENSTRAHLUNG Sidereal Time Variations of Cosmic Rays).—A. Corlin. (*Naturwiss.*, 9th Jan., 1931, Vol. 19, No. 2, pp. 37–39.)

EIN EXPERIMENTELLES ARGUMENT FÜR DEN STELLAREN URSPRUNG DER ULTRASTRAHLUNG (An Experimental Argument for the Stellar Origin of Cosmic Radiation).—V. F. Hess. (*Naturwiss.*, 12th Dec., 1930, Vol. 18, No. 50, pp. 1094–1096.)

EVIDENCE FOR A STELLAR ORIGIN OF THE COSMIC ULTRA-PENETRATING RADIATION.—V. F. Hess. (*Nature*, 3rd Jan., 1931, Vol. 127, pp. 10–11.)

IRREGULAR LICHTENBERG FIGURES DUE TO THE PRESENCE OF RESISTANCE AND INDUCTANCE IN SERIES WITH THE ELECTRODE.—T. Terada. (*Mem. Kyoto Coll. Sci.*, Vol. 13, 1930, pp. 281–290.)

CONTINUOUSLY-RECORDING KLYDONOGRAPH.—F. A. Foerster. (*Elek. im Bergbau*, 19th Aug., 1930, Vol. 5, pp. 156–159.)

A clockwork-driven film gives continuous records for seven days.

AURORA DISPLAY AND MAGNETIC DISTURBANCE.—J. P. Rowland. (*Nature*, 17th Jan., 1931, Vol. 127, pp. 89–90.)

A letter describing a case of a simultaneous auroral display and magnetic disturbance, occurring on December 20th, 1930. The chief feature of interest is that "the auroral light persisted while the declination value was falling rapidly, and ceased at practically the same moment as that fall ceased." From this it is deduced that if the cause of the disturbances be a stream of ionised particles emanating from the sun and reaching the earth's upper atmosphere, the charge carried by the particles must be negative. The magnetic disturbance was one of an unbroken sequence at approximately 27 days interval, persisting since December, 1929.

A LOW AURORA AND ITS EFFECT ON A RADIO RECEIVER.—(*Nature*, 17th Jan., 1931, Vol. 127, p. 108.)

A note of an interesting case of a Canadian aurora which extended to the ground and surrounded a house, causing absolute quietness of a radio set.

SUR LA VARIATION DIURNE DES COURANTS TELLURIQUES ENREGISTRÉS À L'OBSERVATOIRE DU PARC SAINT-MAUR (The Diurnal Variation of the Earth Currents Registered at the Parc St. Maur Observatory).—P. Rougerie. (*Comptes Rendus*, 29th Dec., 1930, Vol. 191, pp. 1465–1467.)

ZUR KATHODENSTRAHLUNG DER SONNE (Radiation of Electrons from the Sun).—H. Rudolph. (*Naturwiss.*, 16th Jan., 1931, Vol. 19, No. 3, p. 66.)

A letter suggesting that an explanation of the daily variations of the terrestrial magnetic field may be found in the streams of electrons emitted by the sun. These may also give rise to thunderstorm voltages of the order of 10^9 volts. The aurora borealis may be due to streams of negatively charged particles leaving the earth.

SUR LA CONFUSION DES EFFETS DE LA FOUDRE PROPREMENT DITE AVEC CEUX DE LA MATIÈRE FULMINANTE (On the Confusion of the Effects of a True Lighting Flash with those of the Fulminant Matter).—E. Mathias. (*Comptes Rendus*, 29th Dec., 1930, Vol. 191, pp. 1420–1422.)

For previous papers on the writer's theory, *see* 1930 Abstracts, pp. 94–95.

MESSUNGEN VON GEWITTERÜBERSPANNUNGEN MITTELS STAFFELFUNKENSTRECKE (Measurement of Over-Voltages in Thunderstorms by means of Echelon Spark Gaps).—H. Heyne. (*Arch. f. Elektrot.*, 7th Nov., 1930, Vol. 24, No. 4, pp. 469–502.)

BEOBACHTUNG EINES KUZELBLITZES (An Observation of Ball Lightning).—W. Westphal. (*Naturwiss.*, 2nd Jan., 1931, Vol. 19, No. 1, pp. 19–20.)

LIGHTNING PROTECTORS USING IONISED GASES.—(French Pat. 689767, Thomson-Houston Company, pub. 11th Sept., 1930.)

Involving the principle referred to in Feb. Abstracts, p. 91 (Franck). For a long summary, see *Rev. Gén. de l'Élec.*, 27th Dec., 1930, Vol. 28, p. 225D.

PROPERTIES OF CIRCUITS.

ÜBER EINIGE UNTERSUCHUNGEN AN HOCHFREQUENZLEITUNGEN (Some Investigations on H.F. Conductors [Feeders]).—H. O. Roosenstein. (*Telefunken-Zeit.*, Dec., 1930, Vol. 11, No. 56, pp. 37–44.)

Traverses part of the ground covered by the *Zeitschr. f. hochf. Tech.* paper (January Abstracts, p. 36). The final section deals with methods of matching the feeders to the aerial system, either

by transformers, by the writer's "transformation lines" (feeder-elements of length $\lambda/4$, connected between source and load circuit: the correct value of characteristic impedance, in the example worked out, was obtained by the parallel connection of several wires), or by Rüdenberg's "transformation lines" in which the impedance alters gradually along the feeders. This last method has the advantage of a transformation ratio independent of frequency, but it is less simple in construction and the lines are often too long in practice.

THE DESIGN OF TUNED CIRCUITS TO FULFIL PREDETERMINED CONDITIONS.—A. L. M. Sowerby. (*E.W. & W.E.*, Jan., 1931, Vol. 8, pp. 23–24.)

"Much time may be consumed in attempting, by trial and error, to find a satisfactory compromise [between high stage-gain and over-sharp tuning, in the tuning circuits for a r.f. amplifier], whereas it is perfectly possible to prescribe a definite sharpness of tuning and a definite stage-gain, and then to calculate quite simply the resistance and inductance which will be required in the tuned circuit." The necessary equations are given and an example worked out.

ANALYSIS OF UNIFORM R.F. AMPLIFICATION.—E. A. Uehling. (*Electronics*, Dec., 1930, pp. 414–416.)

Equations are derived relating to the method of obtaining uniformity of amplification by the introduction of a tuned circuit, in series with the primary of the r.f. transformer and coupled inductively to the secondary with a coupling 180° out of phase with the principal coupling to the secondary. They are directly applicable to amplifiers using screen-grid valves.

THE DESIGN OF HIGH FREQUENCY TRANSFORMERS.—W. G. Baker. (*Trans. Inst. of Eng.*, Australia, 1928, Vol. 9, pp. 107–128.)

From author's summary:—The present paper deals with the design of high frequency transformers to obtain the maximum possible amplification. The cases dealt with include (i) tuned secondary with untuned primary, (ii) tuned primary with untuned secondary, (iii) primary and secondary tuned to the same frequency. The first of these arrangements is shown to offer advantages over the others [for broadcast reception]. By proper design, the amplification of a valve and its transformer can be made nearly maximum over the tuning range of the set. The variation of amplification over the band of broadcast wavelengths can be made less than 8 per cent. from the maximum at each wavelength.

PRE-SELECTION.—W. I. G. Page. (*Wireless World*, 5th Nov., 1930, Vol. 27, pp. 518–520.)

The writer refers to the inability of the screen-grid valve in ordinary tuned circuits to accept signals larger than a small fraction of a volt without introducing the form of interference known as cross-modulation. It is shown that, while a pre-r.f. volume control does much to mitigate the trouble, the essential requisite is selectivity in the first tuned circuit, in which a resonance curve of rectangular form such as that of a band-pass filter is highly desirable. The greater the dynamic resistance of the tuned anode and tuned grid intervalve couplings the greater is the tendency towards cross-modulation.

SCREEN-GRID VALVE AS LOW-FREQUENCY AMPLIFIER.—D. McDonald. (*Wireless World*, 12th Nov., 1930, Vol. 27, pp. 536–538.)

The author gives a method of detection and low-frequency amplification in which stage-gains of over 200 are shown to be possible, owing to the negligible input impedance of the screen-grid valve. Use is made of an automatic compensating device to keep the screen voltage below that of the anode. This consists in deriving the screen-grid voltage direct through a high resistance from the anode, fixing the voltage of the screen to earth by a condenser in the earth lead of reasonably small impedance compared with the resistance.

THE THEORY OF THE VALVE AMPLIFIER.—S. O. Pearson. (*Wireless World*, 22nd Oct., 1930 Vol. 27, pp. 460–462.)

THE THEORY OF THE SUPERHETERODYNE.—A. L. M. Sowerby. (*Wireless World*, 1st Oct., 1930, Vol. 27, pp. 393–397.)

An explanation of the basic principles.

TUNED CONDENSER-COUPLED AMPLIFIERS.—L. Cohen. (*Electronics*, Oct., 1930, pp. 340–341.)

THE MAGNETIC FIELD OF CIRCULAR CURRENTS.—H. Nagaoka. (*Proc. Phys.-Math. Soc. Japan*, Series III, Vol. 4, pp. 8–9.)

"The expansion in q-series is applied to obtain expressions for the magnetic force of a single coil and of Gaugain-Helmholtz coils, at points not far from the axis, in powers of co-ordinates."

QUADRIPOLE THEORY.—J. Wallot: F. Strecker and R. Feldtkeller. (*Wiss. Veroff. Siemens-Konz.*, No. 2, Vol. 8.)

TRANSMISSION.

ANWENDUNG VON RAUMLADEGITTERRÖHREN ZUR AMPLITUDEN-MODULATION (The Employment of Space-Charge-Grid Valves for Amplitude Modulation).—F. Below and H. E. Kallmann. (*Zeitschr. f. hochf. Tech.*, Dec., 1930, Vol. 36, pp. 209–211.)

Modulation methods should avoid the following errors:—the production of harmonics, frequency- and amplitude-distortion of the modulating frequencies, and de-tuning of the carrier wave. They should also be applicable to as wide a range of wavelengths as possible, and to as wide a range of current-strengths.

The writers claim that the method here described avoids all these errors. It consists in controlling the amplification of an intermediate amplifier stage in a separate drive transmitter, by altering the slope of the characteristic. To avoid the generation of harmonics, the practically straight part of the curve is worked on, and advantage is

taken of Below's investigations on the space-charge-grid valve (1929 Abstracts, p. 44), the slope of the curve being controlled by the potential of the space-charge grid.

Thus in an example given, a U.Z 100 D is used with an anode voltage of 70, a control grid voltage of − 1.5 and a space-charge grid voltage of + 14 volts; the slope is then $S_0 = 1.0$ mA./v. A modulation of peak value 6 v. superposed on the d.c. + 14 v. causes the slope to vary from $S_1 = 0.5$ to $S_2 = 1.5$, giving an amplitude modulation of 50 %. To obtain higher percentages of modulation (up to 100 %) a push-pull circuit is used.

GRID-D.C. MODULATION WITH MODULATOR FILAMENTS AND GRID BIAS SUPPLIED BY RADIO FREQUENCY CURRENTS. (German Pat. 500726, Telefunken, pub. 3rd July, 1930.)

An arrangement very similar to that dealt with by Weichart and Langewiesche (Jan. Abstracts, p. 38.)

AN ANALYSIS OF HIGH MODULATION TRANSMISSION. —G. F. Lampkin. (*Electronics*, Oct., 1930, pp. 326–328.)

Three methods are discussed of modifying the ordinary Heising circuit so that 100 % modulation can be obtained without distortion.

THE PHYSICAL REALITY OF SIDE-BANDS.—Colebrook.

(*See* under "Reception.")

UNTERSUCHUNGEN AN AMPLITUDEN- UND FREQUENZMODULIERTEN SENDERN (Investigation of Transmitters with Amplitude and Frequency Modulation [Measurement of Degree of Modulation, Non-Linear Distortion, etc.]).—W. Runge. (*E.N.T.*, Dec., 1930, Vol. 7, pp. 488–494.)

For certain purposes other than ordinary control purposes, a method is necessary which is independent of rectification and its liability to introduce its own distortion. The writer describes and illustrates the Telefunken measuring apparatus based on the Grützmacher procedure, in which the frequency-mixture to be investigated is heterodyned by a local oscillator and the square of the product passed to an a.c. indicator tuned to a frequency smaller than the smallest difference-frequency in the mixture [a multi-stage l.f. amplifier is used here, tuned to 15 cycles/sec.]. If then the local oscillator explores the whole frequency range involved, it will produce a deflection of the indicator each time it meets a partial frequency in the mixture; this deflection is proportional to the amplitude of the partial frequency.

The apparatus comprises the local oscillator; the "squaring" circuit to which the signal-band and its superposed oscillations are led—this uses a valve biased to the lower bend (the slight deviation from the quadratic form in the rectification being made negligible by keeping the amplitude of the local signal large compared with all the partial frequencies); and the tuned a.c. indicator circuit. Particular precautions are taken to avoid undesired reactions.

The writer describes how the apparatus measures, in a very easy way, the amount of amplitude-frequency- and phase-modulation present, and also the amplitudes of the higher harmonics and combination frequencies and thus the factor of non-linear distortion.

SUR LE POSTE ÉMETTEUR À QUARTZ DE PONTOISE ([The Distortion Characteristic—Degree of Modulation/Frequency—of] the Quartz-controlled Pontoise Transmitter).—Bigorgne and Vigneron. (*Ann. des P.T.T.*, Nov., 1930, Vol. 19, pp. 990–993.)

The station is for telephonic communication with Saïgon. The method of obtaining the curve is described, and an example given (30.4 m. wave). Between 100 and 3,000 p.p.s., $D \left(= \log_e \frac{k_{800}}{k_f} \right)$ ranges between the extremes 0.055 and 0.07. Above 3,000 p.p.s. it increases rapidly, reaching 0.32 at 5,000 p.p.s., but the curve shows that the transmitter is correct for its purpose.

EIN EINFACHER EXPERIMENTELLER NACHWEIS DER TRÄGERFREQUENZSCHWANKUNGEN BEI AMPLITUDENMODULIERTEN SENDERN (A Simple Experimental Indication of Carrier Frequency Variation in Amplitude-Modulated Transmitters).—J. Fuchs. (*Zeitschr. f. hochf. Tech.*, Dec., 1930, Vol. 36, p. 219.)

If a harmonic of the station in question is heterodyned, the interference note will be pure both during silence and during modulation, provided there is no frequency modulation mixed with the amplitude modulation. The note will be spoiled, except during silence, if frequency modulation of sufficient extent is present, and the higher the order of the harmonic the smaller is the amount of frequency modulation required to spoil the note. Extremely small degrees of frequency modulation can thus be detected by making use of the 20th or 30th harmonic: most broadcasting stations give evidence of this effect on their 4th harmonics.

THE FREQUENCY VARIATION OF VALVE GENERATORS: CHARACTERISTICS OF THE HARTLEY OSCILLATOR AND THE STABILISING ACTION OF EXTERNAL ANODE RESISTANCE.—S. Ishikawa. (*Journ. Inst. Teleg. and Teleph. Eng. Japan*, Sept., 1930, p. 833.)

In Japanese. The insertion of 1,500 ohms in the anode circuit stabilises a Hartley oscillator (using a UX201-A valve) with an accuracy of one part in 100,000 at 100 kc., with voltages varying 66 % above and below the rated anode voltage and 40 % above and below the rated filament voltage; the normal characteristics may be reversed by increasing the anode resistance above the critical value.

ARRANGEMENT FOR MAINTAINING CONSTANT THE FREQUENCY OF A TRANSMITTER.—(German Pat. 499341, Lorenz, pub. 5th June, 1930.)

The transmitter is coupled through an intermediate circuit to a double circuit containing two crystal-controlled bridge circuits: these two circuits are so de-tuned with regard to the working frequency that the rising branch of one resonance

curve cuts the falling branch of the other at the working frequency. By means of opposed rectifiers, the currents in the crystal-controlled circuits act differentially on a common centre-zero meter, whose pointer will indicate zero when the transmitter frequency is correct. The meter may be provided with contact arrangements so as to regulate the frequency automatically: or the rectified currents from the two circuits may be used to control the bias magnetisation of an iron-cored choke in the transmitting circuit.

Changing the Wavelength of a Crystal-Controlled Short Wave Transmitter.—(German Pat. 501615, Telefunken, pub. 5th July, 1930.)

To get over the difficulty in adjusting the wavelength of a crystal-controlled transmitter, the carrier is modulated by a local oscillator and one side frequency separated out for use: it can be adjusted by altering the modulating frequency, and an accidental frequency change in the local oscillator only produces a small percentage change in the used wave.

The Simplest Short Wave Self-exciting Circuit.—Y. Haraguchi. (*Journ. Inst. Teleg. and Teleph. Eng. Japan*, Aug., 1930, p. 739.)

In Japanese. The writer discusses the merits and defects of the various generating circuits used in practice, taking into consideration stray circuit constants such as the inter-electrode capacities. He then deduces what he considers the simplest possible satisfactory circuit and gives some experimental results obtained with this.

Avoidance of Reaction from Amplifier Stages on to Drive Circuit in Short Wave Transmitters.—(German Pats. 509166 and 509715, Radio Corp.: Kolster Brandes, pub. 4th and 11th Oct., 1930.)

In the first patent, the drive circuit communicates its power to the amplifier by way of a feeder about a wavelength in length; in the second patent, by way of radiation from a small auxiliary aerial.

Push-Pull Ultra-Short Wave Generator with Symmetrical Double-Filamented Valve.—(German Pat. 509164, Hollmann, pub. 4th October, 1930.)

A single grid (there are no anodes) lies midway between the two filaments, and voltages are so chosen that each filament acts as a braking electrode to the electrons from the other filament.

Hummer Directional Transmitter for Ultra-Short Waves.—(German Pat. 510813, Telefunken and Ludenia, pub. 23rd October, 1930.)

Especially for small portable stations: a dipole arranged along the axis of a concave cylindrical mirror: its central ends are connected, through r.f. chokes, to the poles of a battery, and are joined through a hummer or buzzer. Presumably used in the tests referred to in 1929 Abstracts, pp. 507–508.

Colloidal Spark Gap for Ultra-Short Wave Generation.—(German Pat. 499573, Hildebrand, pub. 10th June, 1930.)

Deals with the use of colloids, *e.g.*, metallic colloids, for the special spark gaps used for the production of ultra-short waves. By altering the density of the colloid, the wavelength may be changed.

Four-Electrode Valve in Brake-Field Circuit, for Increased Power in Ultra-Short Wave Generation.—(German Pat. 505607, Esau, pub. 27th August, 1930.)

One oscillatory circuit is connected between anode and the grid next to it, and another between the two grids. The grid next to the filament has a high positive voltage, the other grid a negative voltage. A dipole aerial is connected to the anode and to the grid next to the filament.

Push-Pull Ultra-Short Wave Generator with Tuned Circuit Connecting the Filament Circuits.—(German Pat. 510727, Esau, pub. 22nd October, 1930.)

An increase of power (up to 5 times) is obtained by connecting the filament circuits by a tuned circuit. Either separate batteries or a common battery may be used: in the latter case one pole is connected to the lead joining one end of the two filaments, while the other pole goes to a point on the inductance of the tuned circuit, or to the junction of the inductances if two tuned circuits are used. *Cf.* 1930 Abstracts, pp. 99 (Esau) and 505–506 (Dennhardt).

The Influence of Certain Factors [Filament Temperature] on the Output of a Triode Oscillator.—G. S. Field: C. H. West. (*Canadian Journ. of Res.*, Dec., 1930, Vol. 3, pp. 510–515.)

West, working on 5.17 m. waves, claimed to have observed a variation of radiated energy with the intensity of illumination (1929 Abstracts, p. 566). Field investigates this and concludes that the effects were *temperature* effects on the filament; his tests show that even when working at the rated value of filament current, the variation of radiated energy with filament current fluctuations may be very considerable.

Simultaneous Transmission of Beacon Signals and Telephony.—U.S. Bureau of Standards. (*See* abstract under "Directional Wireless.")

RECEPTION.

Ultra-Short Wave Receiving Circuit.—(German Pat. 496844, Esau, pub. 28th April, 1930.)

Receiving circuits in which a tuned circuit is connected between anode and grid, and the anode potential is applied to a tapping on this circuit, give trouble in the case of ultra-short waves. According to the invention, the difficulty is overcome by connecting the anode supply to a second tuned circuit of the same frequency, and joining the two circuits by a single lead.

INTERACTION IN AMPLIFIERS, WITH SPECIAL REFERENCE TO COMMON IMPEDANCE IN FILAMENT CIRCUITS.—L. Bainbridge-Bell. (*E.W. & W.E.*, Jan., 1931, Vol. 8, pp. 18–20.)

Accidental retroaction by resistance coupling due to resistance in common leads, in the common source of high tension, and in the grid bias battery is often met with, and ways of counteracting it are well known. The writer deals with another source of unwanted retroaction, only experienced when a high overall amplification is employed, and very seldom suspected: namely, coupling due to common impedance in the *filament* battery circuits. He investigates the mechanism of this coupling effect, and discusses many ways of preventing it. Chokes in the filament leads, and the use of indirectly heated cathodes (Lubszynski, 1930 Abstracts, pp. 170 and 408) both have their disadvantages, and the best solution was found to lie in preventing the a.c. component of the anode current from flowing through the l.t. battery, by connecting an additional, matched condenser to the +ve end of the filament to balance the decoupling condenser connected to the −ve end (the latter condenser being essential in high gain amplifiers as part of the decoupling arrangement to prevent retroaction due to the common h.t. source).

DEVELOPMENTS IN BROADCAST RADIO RECEIVING APPARATUS.—A. J. Gill and A. G. McDonald. (*P.O. Elec. Eng. Journ.*, Oct., 1930 and Jan., 1931, Vol. 23, Parts 3 and 4, pp. 216–219 and 321–324.)

"An interesting departure from the more usual designs," is the use of ordinary battery-type valves heated by the d.c. output of a metal-oxide rectifier. "A super-heterodyne receiver, having adequate h.f. selectivity and in which a flatly tuned high gain i.f. amplifier is combined with a correctly designed band-pass filter of the Campbell type to give the necessary selectivity, is probably the ultimate goal in receiver design." "It may perhaps be of interest to note that modern valves are surprisingly variable as regards measured characteristics, and that of ordinary receiving valves tested as high a proportion as 30 % are considerably below the makers' published specification. The pumped, as distinct from the gettered valve, is still the best if a long life be desired."

A long section deals with rectifiers, particularly the mercury vapour and gas-filled types. The January instalment gives short comments on some individual receivers, pick-ups, mains units and loud speakers; also on selectivities, screening, and power grid detection.

RADIO DEVELOPMENTS AND FUTURE TRENDS [IN U.S.A.].—(*Electronics*, Jan., 1931, pp. 452–454.)

Special attention is paid to the cheap "Midget" or "Mantel" type of set which was so popular in 1930. The possibilities of improvement are discussed: one is the use of the "variable mu" tetrode developed by Snow and Ballantine (*see* under "Valves and Thermionics" and "Measurements and Standards"), which "threatens to clean up a number of untidy spots not only in the very small set but in larger radios as well." It is much more difficult to overload than the ordinary screen-grid valve; as automatic volume control, it gives a very large range and will probably do away with the need for a local-distance switch.

"The superheterodyne was the circuit advance of 1930. In 1931 it will continue to hold centre of attention. In the opinion of many engineers the superheterodyne is the circuit *par excellence*, theoretically at least. Screen-grid intermediate amplifiers with exceptionally high gain, and band-pass filters, will enhance their value to the user" [*cf.* Gill & McDonald, preceding abstract].

"1931 will see greater extension of high modulation. Prodding by the Federal Radio Commission will force stations either to increase their modulation or to decrease their carrier. Further synchronisation will undoubtedly occur, as will further extension of high power and the use of vertical antennas to reduce sky wave."

GRUNDSÄTZLICHES ZUR GÜTEBEURTEILUNG VOM RUNDFUNK-EMPFANGERN (Fundamental Considerations in Judging the Figure of Merit of a Broadcast Receiver).—A. Clausing. (*E.N.T.*, Dec., 1930, Vol. 7, pp. 477–488.)

Based on prolonged work at the Siemens and Halske laboratories. Speaking generally, the merit of a broadcast receiver depends on a combination of the overall amplification as a function of aerial e.m.f. and wavelength, and the selectivity. Purity of reproduction is measured by the value of the "klirr"-factor as a function of the aerial e.m.f. and of the modulation frequency.

The sound output necessary is *not* proportional to the cubic space of the room: measurements show that the former need increase less rapidly than the latter, owing to the fact that the absorption increases as the square of the dimensions and the space as the cube. Curves are given representing direct measurements of the necessary valve output in mw/m³ for rooms ranging from 30 to 5,000 m³. The mean curve (based on the average judgment of several observers) gives values of nearly 9 mw/m³ for 30 m³ rooms and nearly 3 mw/m³ for 1,000 m³ rooms.

The paper then deals with the behaviour of the whole installation:—(i) aerials and the question of interference: indoor *versus* outside aerials (the available voltage in these two types is taken throughout the paper as 0.3 mv. and 3 mv. respectively); (ii) loud speaker and output valve: frequency independence between 50 and 5,000 cycles/sec. is taken as the requirement: non-linear distortion—tests show that for an 8-phon volume at 3 m. distance the necessary grid-a.c. is well over 10 v. at 50 cycles, about 7 v. at 200, 6 v. at 5,000, and only 0.8 v. at 800 cycles—owing to the ear's selective sensitivity; (iii) the detector: leaky-grid or anode-bend, the former working best between 0.1 and 0.8 v., the latter inferior till 0.8 v. is reached and thereafter superior, except from the point of view of reaction coupling at small signal strength: Siemens and Halske have therefore suggested a two-anode valve, the anodes being so dimensioned that the one gives twice as large a "durchgriff" as the other and can be used in the

reaction circuit, while the other works on the lower bend as an anode-bend detector; (iv) r.f. amplification; (v) judging the merit of the whole receiver.

REICHWEITE UND LAUTSTÄRKE BEI VERSCHIEDENEN EMPFÄNGERTYPEN (Range and Volume with Various Types of Receivers).—G. Büscher. (*Die Sendung*, 9th Jan., 1931, Vol. 8, pp. 21–22.)

A table of 28 items is given which is best described by quoting a sample line:—

Item 20. 5.	2*H*.*A*.2*N*	*Zi*, *Ra*	*LL*6.*TTT*.
		Ho	*LL*7.*TT*.

The interpretation of this is:—a 5-valve receiver (2 r.f. stages, detector without reaction, 2 l.f. stages) under the specified conditions will give (*a*) with indoor aerial or frame, medium loud-speaker strength (*LLL* would be "great loud-speaker strength") on a 1.5 kw. European station (4 would have been a "10 kw. European station") with very high selectivity; (*b*) with an outside aerial, the same medium loud-speaker strength on a 50 kw. station outside Europe, with high (not very high) selectivity. The table ranges from a crystal receiver on an indoor aerial to an 8-valve superheterodyne on an outside aerial.

PARIS SHOW.—(*Wireless World*, 22nd October, 1930, Vol. 27, pp. 463–466.)

An account of the French Radio manufacturers' annual exhibition in 1930. Special attention is drawn to the tendency for a stronger representation of the straight multi-stage r.f. receiver as opposed to the ubiquitous superheterodyne. All-mains sets were much in evidence, while moving-coil loud speakers, hitherto rather restricted in supply owing to the patent royalty, were to be seen in the more ambitious receivers and radio-gramophones.

THE TREND OF PROGRESS.—(*Wireless World*, 1st October, 1930, Vol. 27, pp. 377–384.)

A survey of progress based on a critical inspection of all the apparatus displayed at the Olympia Radio Show, 1930. The opinion is expressed that sets are capable of better performance than hitherto in range, quality of reception and ease of control. Design and manufacturing details give improved appearance and increased reliability.

FADING ELIMINATION BY INTERRUPTED SIGNALS IN TELEGRAPHY.—(German Pat. 490600, Telefunken, pub. 10th June, 1930.)

The received signals are interrupted in rapid succession in order that those signals, travelling by different paths, which are liable to cause interference effects may arrive at the receiver during the intervals, which can be regulated to give the best results at the moment.

NEUES ÜBER SELEKTIVITÄTSERHÖHUNG MITTELS SPERRKREIS (New Developments in the Use of Wave Traps for Increasing Selectivity).—R. Rechnitzer. (*Telefunken-Zeit.*, Dec., 1930, Vol. 11, No. 56, pp. 31–37.)

The popular Telefunken T40 receiver, with capacitive aerial coupling and volume control, works particularly well in combination with the Telefunken wave-trap, which is furnished with a switch so that it can be connected as a parallel *LC* rejector circuit in series with the aerial (for cases where the signal frequency is smaller than the interfering frequency) or as a series *L* and *C* acceptor circuit shunting the receiver (for cases where the signal frequency is greater than the interfering frequency). By this arrangement the wave-trap's effective resistance to the signal frequency is always *inductive*, and so can form an additional tuned circuit with the capacities of the aerial and of the double condenser forming the capacitive r.f. potentiometer for regulating volume. As a final result, not only is the selectivity increased but also the sensitivity (sometimes as much as 10 : 1).

ZUSATZGERÄT ZUR ERHÖHUNG DER ABSTIMMSCHÄRFE UND VERMINDERUNG VON STÖRUNGEN (Auxiliary Attachment [for Broadcast Receivers] for Increasing Selectivity and Decreasing Interference).—T. Eckert. (*E.N.T.*, Dec., 1930, Vol. 7, pp. 510–511.)

This device has just gained the inventor the Heinrich-Hertz silver medal, and was acclaimed by Wagner as giving the ordinary 4-valve broadcast receiver the selectivity of a "high class, difficult-to-adjust, multi-valve apparatus." It includes:—(*A*) an aerial-tuning circuit with a fixed inductive coupling to a tuned circuit which is connected to the input terminals of the actual receiver through a non-inductive resistance of 5, 20 or 100 thousand ohms, as desired. This resistance adjustment not only controls the coupling between the auxiliary attachment and the receiver, but also markedly decreases trouble from interference of an impulsing nature. (*B*) An absorption circuit for eliminating the local station, coupled inductively to the aerial-tuning circuit. (*C*) A single triode circuit which can be connected to (*B*) when the ordinary absorption circuit finds the interference too strong to cope with. When this valve circuit is in use, the circuit (*B*), tuned to the interfering frequency, controls the grid, while the anode circuit is coupled inductively (a variable resistance adjusts this coupling) to the input circuit leading to the receiver, so that the interfering signals are opposed and neutralised.

On pp. 511–512, Leithäuser reports on the tests on the Eckert device which led to the medal award.

STÖRBEKÄMPFUNG (The Elimination of Interference [due to Electrical Machines and Apparatus]).—(*Rad.*, *B.*, *F. f. Alle*, Jan., 1931, Vol. 10, pp. 17–29.)

(1) Commercial apparatus for suppressing interference; (2) the identification of the source of interference; (3) the practical application of the cure.

ÉLIMINATION DES PARASITES EN T.S.F. PAR LE SYSTÈME BAUDOT-VERDAN (Elimination of Interference in Wireless by the Baudot-Verdan System).—E. Montoriol. (*Ann. des P.T.T.*, Oct., 1930, Vol. 19, pp. 875–901.)

A description of the latest developments in this system (*see* 1928 Abstracts, p. 406; 1930, p. 221), which is said to give, with 2 repetitions, a speed of

70 w.p.m. under conditions of interference which prevent "the other systems" from working at all, or (with one repetition only) to give 100 w.p.m. when the others are painfully working at 20–25 w.p.m. The Comp. Gén. de T.S.F., Telefunken, R.C.A. and the Marconi Company have each recently bought the rights of exploiting it.

Choke Coils Eliminate Radio Interference.—A. S. Warner. (*Elec. World*, 25th October, 1930, pp. 780–781.)

Radio interference in a thickly populated residential section in the immediate neighbourhood of a double-circuit 66 kv. line was eliminated by introducing choke coils in the circuits where they enter the residential section.

Reduction of Distortion and Cross-Talk in Radio Receivers by Means of Variable-Mu Tetrodes.—Ballantine and Snow. (*See* under "Valves and Thermionics.")

Quality Reception.—John Harmon. (*Wireless World*, 1st, 8th, 15th and 22nd Oct., 1930, Vol. 27, pp. 368–372, 413–416, 450–453, and 478–480.)

A discussion on how best to arrange the circuits of a receiver, taking into account tone control and frequency response, with the object of securing reproduction that is a true replica of the original. The r.f. and l.f. stages are dealt with, and careful attention is given to the problem of input impedance.

Band Pass and Better Selectivity.—W. I. G. Page. (*Wireless World*, 24th September, 1930, Vol. 27, pp. 298–300.)

Concerning the advantages of the double-humped resonance curve. A popular summary of the principles of the band pass filter, emphasising the need for the rectangular resonance curve if both selectivity and quality are to be obtained at the same time.

The Physical Reality of Side-bands: A Note on the Rectification of a Modulated Continuous Wave.—F. M. Colebrook. (*E.W. & W.E.*, Jan., 1931, Vol. 8, pp. 4–10.)

Author's summary:—"The reception and rectification of a modulated continuous wave is considered theoretically and experimentally with special reference to the variation of the modulation frequency output with the tuning of the receiving circuit. The physical reality of the side frequencies is demonstrated, and their effect on the shape of the tuning curve is shown. A brief discussion is also given of the side-band cut-off effect, *i.e.*, the variation of amplitude of the modulation frequency output with modulation frequency."

The writer ends by remarking that in addition to demonstrating conclusively the physical reality of the side frequencies of a modulated continuous wave, the paper shows that the reception and rectification of such a wave is a somewhat more complicated matter than is generally realised, and that there is need for a fuller theoretical and experimental investigation of the subject than it has yet received. It is of special interest in relation to broadcast reception.

Effect of Output Load upon Frequency Distortion in Resistance Amplifiers.—H. A. Thomas. (*E.W. & W.E.*, January, 1931, Vol. 8, pp. 11–17.)

After referring to the results of von Ardenne and Stoff, and their statement that in a high amplification-factor resistance-capacity amplifier the frequency response characteristic of the first stage only is of importance, owing to the output load producing an appreciable modification of the input impedance of the previous stage, the writer gives a theoretical and experimental investigation of the difference in the frequency-amplification characteristic of a two-stage r.-c. amplifier followed by a power valve, according to whether the loud speaker is in circuit or short circuited.

The following conclusions are reached:—(*a*) When a loud speaker load is inserted into the power stage of an amplifier, the overall amplification of the preceding amplifier is modified by its presence, and the amplification at high audio-frequencies is dependent on the nature of the output load and is always less than in the no-load case. (*b*) The reduced amplification due to the load at high audio-frequencies *is chiefly dependent upon the anode-grid capacity of the power valve.* This fact was confirmed by increasing this capacity by an added condenser. (*c*) The frequency distorting effect is also largely due to the high effective input-capacity of high-factor stages, this effect being only slightly dependent upon the nature of the output load.

Further experiments, with three stages of low-factor valves, lead to the conclusion that such frequency distortion is inherent in any normal type of r.-c. amplifier employing triodes, and that there appears to be no advantage in using a larger number of low-factor stages in cascade.

Some Properties of Grid Leak Power Detection.—F. E. Terman and N. R. Morgan. (*Proc. Inst. Rad. Eng.*, Dec., 1930, Vol. 18, pp. 2160–2175.)

Authors' summary:—It is shown theoretically that grid leak power detection can be obtained without undue distortion provided the grid condenser reactance X to the modulation frequency, and the grid leak resistance R, are related to the degree of modulation m in such a way that $X/R \geq m/\sqrt{1 - m^2}$. The load limit of the grid leak power detector is the point where plate rectification becomes appreciable, *i.e.*, when the straight line part of the plate characteristic is exceeded. Theory is developed which indicates that the maximum carrier voltage a grid leak power detector will handle is slightly less than one-half the input voltage that the tube will take as a properly adjusted amplifier operating at the same plate voltage; and that the maximum undistorted audio-frequency output voltage of the detector is in the neighbourhood of one-third the output voltage developed by the corresponding amplifier. The equivalent input resistance of a grid leak power detector is proved to be greater than one-half the grid leak resistance.

Experimental results are given which verify the theoretically determined point at which distortion becomes excessive. These results indicate that the grid leak power detector is more sensitive than the *C* bias power detector, and will ordinarily give at least as much undistorted output when operated at the same plate voltage.

A New Power Detector System.—P. G. Weiller. (*Rad. Engineering*, Oct., 1930, Vol. 10, pp. 33–34.)

The writer modifies the usual power grid detector circuit by obtaining his grid bias by the action of the plate current on a non-linear resistance (*e.g.*, magnesium/copper sulphide combination). Since the system works on the normal grid bias for which the valve was designed, the plate impedance remains normal and a l.f. transformer of customary design can be used; whereas in the usual circuit, with its high grid bias, the plate impedance is very high and a very high impedance transformer primary is necessary.

Band-Pass Superheterodyne.—A. L. M. Sowerby and H. B. Dent. (*Wireless World*, 5th and 12th Nov., 1930, Vol. 27, pp. 512–517 and 552–557.)

A constructors' frame aerial set embodying the supersonic heterodyne principle and band-pass tuning for the intermediate frequency amplifier. Screen-grid valves are employed in r.f. and i.f. amplifiers, also for the first detector.

The Wireless World Four.—F. H. Haynes. (*Wireless World*, 15th and 22nd Oct., 1930, Vol. 27, pp. 426–431 and 467–471.)

Description of a receiver for home construction embodying band-pass tuning, single-dial control, pre-r.f. volume control, complete coil and valve screening, tuned-grid intervalve couplings, ganged wave-change switching, power grid detection, high-voltage compensated-pentode output, all-mains operation and provision for gramophone. Designed for housing in a standard radio-gramophone cabinet.

The Band Pass Three. (*Wireless World*, 17th September, 1930, Vol. 27, pp. 262–267.)

Describing the construction of a general purpose receiver which, by virtue of its input filter, has an ample margin of selectivity. The receiver comprises a r.f. amplifying stage with transformer coupling, a regenerative grid detector and a single transformer-coupled l.f. magnifier. The input volume control takes the form of a differential condenser in the aerial circuit.

An All-Wave Radio Receiver for Aircraft.—R. S. Kruse. (*Electronics*, Oct., 1930, pp. 336–337.)

Grid Bias without H.T. Batteries.—L. G. Veyssière. (*T.S.F. Moderne*, Nov., 1930, Vol. 10, pp. 526–533.)

The first method described, for battery-operated receivers, makes use of the negative charge on the control grid of an oscillator when a high resistance is in series with it. The second method is for a.c. mains-operated receivers.

Volume Control.—C. Whitehead. (*Wireless World*, 8th October 1930, Vol. 27, pp. 400–405.)

An examination of the various methods with explanations of their merits and failings.

Effective Screening.—Part II.—R. L. Smith-Rose. (*Wireless World*, 3rd September, 1930, Vol. 27, pp. 232–234.)

The conclusion of the article referred to in 1930 Abstracts, p. 630. The author discusses how alternating currents penetrate a conductor, and describes reception tests conducted in an experimental room lined throughout with galvanised iron wire netting.

Essential Tests for Component Parts of Electrical Radio Receivers.—H. E. Kranz. (*Rad. Engineering*, Nov., 1930, Vol. 10, pp. 41 and 46.)

The Life of Component Parts.—McM. Silver. (*Ibid.*, pp. 50 and 52.)

AERIALS AND AERIAL SYSTEMS.

Raschet antenni Hertza (The Design of Hertz type Antennæ).—G. A. Uger. (*Westnik Electrotechniki*, Leningrad, June, 1930, Part 1, pp. 225–229.)

In Russian. Starting with the fundamental equations for the distribution of current and voltage in long lines, the design of Hertz type antennæ is considered in three sections as follows:—

1.—*Calculation of the inductance and capacity required to tune an antenna to the operating frequency.*

An expression is derived for determining the total impedance of an antenna, and separate consideration is given to the cases when the antenna is equivalent to (*a*) a pure capacity; (*b*) a pure inductance; (*c*) a pure resistance, and (*d*) an inductance and a capacity in parallel. The calculation of the antenna impedance Z_A is much simplified when the length of the horizontal portion is equal either to an odd number of quarter wavelengths or an integral number of half wavelengths.

It is difficult to excite the antenna in case (*c*), as the coupling requires to be very tight and therefore for this case an auto-transformer coupling should preferably be used. For the remaining cases a transformer coupling with an adjustable condenser (*C*) in each arm of the secondary, the whole being symmetrical, is satisfactory.

The impedance Z of the circuit connected between the aerial terminals must satisfy the condition $\bar{Z} + Z_A = 0$. From this condition and for a given value of secondary inductance L_2, the necessary capacity C can readily be found from the expression $Z = j\left(L_2\omega - \frac{1}{C\omega}\right)$.

2.—*Calculation of radiated power from the value of the current at the base of an antenna.*

An expression and a curve are given for determining the radiation resistance of a Hertz antenna referred to the current node in the horizontal portion. The radiation resistance R_A referred to the base of the antenna can then be found and, knowing the current flowing into the antenna, the radiated power calculated. The calculations are again simplified in the two cases referred to in section 1.

3.—*An antenna considered as a load on the transmitter.*

The impedance into which the transmitter is designed to work must be equal to $\frac{(M\omega)^2}{R_A}$. Knowing R_A, the coefficient of mutual inductance can be found from this relationship. For a given coupling coefficient K and inductance L_1, the value of inductance L_2 can then be determined from the relationship $K = \frac{M}{\sqrt{L_1 L_2}}$.

It appears from the above that a Hertz type antenna can be tuned to a number of different wavelengths. The necessary relationship between the optimum wavelength and the length of the horizontal portion of the antenna is next discussed. It is pointed out that the usual definition of the efficiency of an antenna, *i.e.*, the ratio of the radiation resistance to the total resistance, is not applicable to Hertz type antennæ as losses in these antennæ are very small and their efficiency from this point of view is always nearly 100 %.

It is suggested that the performance of an antenna is better judged by the distribution of the radiated energy in space; for example, by the ratio $\frac{E^2}{W}$ when E is the vector of the electric field in a direction perpendicular to the axis of the antenna and W the total radiated energy. It is shown that this expression has the greatest value when the length of the horizontal portion of the antenna exceeds one half of the operating wavelength by 20 to 25 %.

A numerical example illustrating the design of an antenna is given.

Neuere Messungen an Kurzwellen-Richtantennen (New Measurements on Short Wave Beam Aerials).—A. Gothe. (*E.N.T.*, Dec., 1930, Vol. 7, pp. 494–501.)

It is often questioned whether the theoretical directional effects of beam aerials, both in the horizontal and vertical planes, are actually obtained in practice, and particularly over transatlantic distances. The Telefunken Company have therefore carried out tests on their horizontal-dipole aerial arrays (transmitting and receiving) at close quarters and at transatlantic distances. The present paper deals with these tests. "To sum up, it may be stated that the big Telefunken arrays fully attain the calculated superiority over individual aerials. The horizontal and vertical diagrams measured at close quarters agree well with the calculated ones, and the calculated improvement in field strength is fully confirmed by measurements at transatlantic distances."

The Calculation of the Radiation Characteristics and Radiation Resistances of Aerial Systems.—R. Bechmann. (*Zeitschr. f. hochf. Tech.*, Dec., 1930, Vol. 36, pp. 201–208.)

Second and final part of the paper dealt with in Feb. Abstracts, pp. 96–97.

Beam Arrays and Transmission Lines.—T. Walmsley. (*E.W. & W.E.*, Jan., 1931. Vol. 8, pp. 25–27.)

Abstract of the I.E.E. (Wireless Section) paper. It deals with the author's "T.W." Arrays (vertical and horizontal types) referred to in 1930 Abstracts, p. 410 (Purves), and with the question of feeders. The author defends the open type of feeder as compared with the concentric; he examines the causes of loss, and the influence of the type of array employed on the radiation loss; contrary to the usually accepted belief, open feeders—particularly those used in conjunction with symmetrical types of aerial systems—may have low electrical losses. A discussion follows.

Fading Elimination by Constantly Varying the Angle of Radiation.—(German Pat. 504322, Telefunken, pub. 1st Aug., 1930.)

By means (*e.g.*) of a rotating commutator, which connects in circuit one after another of the elements of a multiple aerial system.

Space Wave Angle Regulated by Switching-in the Suitable Elements of an Aerial System.—(German Pat. 506167, Esau, pub. 29th Aug., 1930.)

Neuere Versuche mit Sendeantennen (New Tests on Transmitting Aerials).—F. Kiebitz (*T.F.T.*, October, 1930, Vol. 19, pp. 303–308.)

Author's summary:—In December, 1929, transmitting aerials were suspended vertically to heights from 100 to 200 metres, and were excited with a 400 m. wave. The results at a distance were judged by field-strength measurements at 6 points between 2–126 km. No increase was found if the aerial was increased above a quarter wavelength. A theoretical consideration of the influence of a conducting earth shows that with a half-wave aerial the maximum radiation cannot lie along the earth's surface, as it does with a quarter-wave aerial, but must turn [more or less] sharply upwards; this explains the above results.

Investigations on Aircraft Aerials.—U.S. Bureau of Standards. (*See* abstract under "Directional Wireless".)

Currents Required to Remove Conductor "Sleet."—J. E. Clem. (*Elec. World*, 6th December, 1930, pp. 1053–1056.)

VALVES AND THERMIONICS.

An Effect of Space Charge in a Gas at Low Pressures.—E. W. B. Gill. (*Phil. Mag.*, January, 1931, Ser. 7, Vol. 11, pp. 95–98.)

"With an ordinary three-electrode valve as used

for wireless purposes it has been found under certain conditions that, when definite potentials are applied to the electrodes, the current passing through the valve from filament to anode can have two or three different values (Gill, *ibid.*, May, 1925). This effect is more readily obtained if the applied potentials are small (from 10 to 30 volts). The potential distribution in the space between the electrodes is different with the different currents, although the potentials of the electrodes themselves are the same.

"A like effect can be obtained with a two-electrode valve if it contains gas at low pressures, the applied potential between the anode and the filament being again small and of the order of that usually quoted as the ionisation potential of the gas." The writer describes experiments with a diode containing helium at 8 mm. Hg. pressure. The higher currents can be obtained for potentials between 22 and 28 v. by increasing to 28 v. and then reducing: but they can also be obtained by applying a temporary magnetic field parallel to the filament while the smaller current is running; so the higher potentials are not essential. All the effects are interpreted as results of negative space charge influences: the effect of this charge is to reduce the electric force near the filament and increase it near the anode; ionisation will only occur when the electrons have reached a certain limiting velocity, and the above distribution of electric force reduces the space over which the electrons are capable of ionising atoms of the gas. If by any chance the large current is set up, this indicates that the number of positive ions is large, the negative space charge is largely neutralised and the region over which the electrons can ionise is increased. The necessary larger supply of positive ions will thus be maintained.

CHARACTERISTIC VELOCITY OF ELECTRONS DIFFUSED FROM METALLIC SURFACES.—G. Bernardini. (*Atti Accad. Lincei*, Vol. 11, 1930, pp. 1096-1099.)

REDUCTION OF DISTORTION AND CROSS-TALK IN RADIO RECEIVERS BY MEANS OF VARIABLE-MU TETRODES.—S. Ballantine and H. A. Snow. (*Proc. Inst. Rad. Eng.*, Dec., 1930, Vol. 18, pp. 2102-2127.)

Authors' summary:—In attempting to control the audio output of a radio receiver employing the present types of tubes by varying the control-grid bias or screen-grid voltage, distortion due to nonlinearity of the output-input voltage relation for the tube, and cross-talk, are encountered at the higher signal voltages. Both effects are largely due to the rapid increase in the higher-order curvature parameters of the tube characteristic which occurs as the grid bias increases negatively, or screen-voltage decreases.

Two tubes, designated as Types 550 and 551, have been developed to reduce these effects. They are shielded tetrodes of which the characteristic has been specially shaped to reduce the higher-order curvature in relation to the transconductance. The desired shape of characteristic is attained by a composite structure by virtue of which the tube acts as a high-mu tube at normal grid biases and automatically changes into a device of low-mu as the grid bias increases negatively.

The 550 tube will handle an input voltage of 15, and the 551, 7 volts, with negligible distortion. These represent improvements of 50 and 25 times over present 24 tubes. Cross-talk is reduced to 1/500th that obtained with the present type at input voltages of 0.1 volt.

A general discussion of the problem of distortion and cross-talk is given from both the theoretical and experimental viewpoints. Both effects are shown to be approximately proportional to the ratio of the third derivative to the first derivative of the plate current-grid voltage characteristic. A factor called the cross-talk factor is defined which represents the ratio of audio output due to the interfering signal to that due to the desired signal. This is shown to vary with the square of the interfering signal voltage. Graphical methods of analysis of distortion and cross-talk in multistage amplifiers are described.

The principal of the variable-mu tube is outlined and a number of structural embodiments illustrated. The paper concludes with curves and a table of characteristics of the type 550 and 551 tubes and the results of tests of reliability, reproducibility, and longevity in the manufactured product.

See also references under "Reception" and "Measurements and Standards."

100 KW. VALVE TYPE C.A.T.10.—W. J. Picken. (*Marconi Review*, Dec., 1930, pp. 22-24.)

TRANSMITTING VALVE WITH TWO GRIDS WITH THEIR OPENINGS STAGGERED. — (German Pat. 501012, Telefunken, pub. 27th June, 1930.)

The two grids are so disposed that there is no direct path from cathode to anode. Electrons penetrating the first grid come against the second, from which secondary electrons are emitted to the anode.

NEW SCREEN GRID VALVE: 424 HIGH GAIN AUDION.—De Forest Company. (*Electronics*, Dec., 1930, p. 444.)

"If a set has a sensitivity of 20 microvolts per metre, with the usual screen-grid tubes, the sensitivity may be increased to 10 microvolts per metre with the new type tubes."

BLUE GLASS VALVES MORE "EFFICIENT" THAN WHITE GLASS VALVES OF IDENTICAL DESIGN.—Arcturus Company. (*Radio Engineering*, Nov., 1930, Vol. 10, p. 52.)

No satisfactory explanation is offered for this effect, which has been noticed consistently.

GRIDLESS TRIODES [TELEFUNKEN "PEG" VALVES].—G. W. O. H. (*E.W. & W.E.*, Jan., 1931, Vol. 8, pp. 1-3.)

An editorial on the paper dealt with in Feb. Abstracts, p. 98.

THE APPLICATION OF A NEW TYPE OF TRIODE VALVE [WITH LOW GRID CURRENT] TO THE DETERMINATION OF HYDROGEN-ION CONCENTRATION WITH GLASS ELECTRODES.—G. B. Harrison. (*Journ. Chem. Soc.*, July, 1930, pp. 1528–1534.)

The valve in question is the "electrometer triode" (Philips) whose grid current ($E_g = -2$ v.) is less than 10^{-14} A. This very low grid current is due to the electrode arrangement, the grid not being situated between filament and plate. The characteristic, for —ve grid potential, is similar in shape to that of an ordinary triode, but its slope is only about 0.03 mA./v. The anode voltage is 4 – 9 v., filament supply 0.7 A. at 2 v.

LOGARITHMIC VALVE CHARACTERISTICS.— —. Fasal. (*Electronics*, Dec., 1930, and Jan., 1931, pp. 442 and 482.)

Summary of an article in *Funk Magazin*. It is suggested that the ordinary curves may be replaced with advantage by curves in which R_p, "durchgriff" and mutual conductance are plotted logarithmically against E_p plotted linearly. Keeping the E_p scale constant in all the curves, it is thus possible to read directly such complex characteristics as the figure of merit ($\mu \times$ mutual conductance) of the valve, and to check the correctness of the curves by seeing whether the ordinates for R_p, "durchgriff" and mutual conductance, for any given value of E_p, give a product of unity. Methods of obtaining the curves directly are given in the original paper; or they can be calculated from the usual curves. "The contrast between the complicated curves of the type generally employed and those proposed is very striking in the case of screen-grid valves. The application to pentodes is also described." *Cf.* Meyer, Jan. Abstracts, p. 42, on the triangular valve diagram.

PENTODE AS DETECTOR AMPLIFIER.—E. Yeoman Robinson. (*Wireless World*, 10th September, 1930, Vol. 27, pp. 238–240.)

The measurement of the power output and distortion for a valve performing the dual function of detection and power amplification cannot follow accepted practice. The article describes a new system of calculation—"a rather roundabout experimental method"—which takes into account the various depths of modulation likely to be met with in broadcast reception.

The dynamic detection characteristics of the A.C./Pen valve when used with resistance coupling in the output circuit are dependent upon the load impedance of the anode circuit of the detector valve and are determined by measurements being made at 50 cycles with appropriate adjustments made to by-pass condensers.

Curves are derived showing the dynamic detection characteristics of the valve for various signal voltages with transformer coupling.

DIRECTIONAL WIRELESS.

À PROPOS DES RADIOPHARES TOURNANTS CONJUGUÉS (Concerning Co-ordinated Rotating Beacons).—P. Franck: C. Bourgonnier. (*L'Onde Élec.*, Dec., 1930, Vol. 9, pp. 553–581.)

The greater part of the December issue is taken up by this argument between Bourgonnier, the expounder of the new Loth system for the guidance of aircraft (1930 Abstracts, p. 217), and Franck, who maintains that whereas the existing types of aircraft beacon give a "canal" of the reasonable breadth of less than 3 km. at a 100 km. range, the Loth beacon would give a corresponding breadth varying from 5 km. to 12 km. according to position along the route; or worse still if the base is very short; and that under the best conditions, a reasonable breadth of 3 km. can only be obtained over a very short part of the route.

Bourgonnier flatly denies all this: the canal does *not* vary in breadth along the route but remains constant (Franck had assumed a constant speed of rotation of the beacons) and would be less than 3.5 km. throughout a 100 km. route. Regarding Franck's estimate of 3 km. breadth at 100 km. with "existing" beacons, he quotes official U.S.A. equi-signal beacon figures as giving 5.2 km. at 100 km.

AERONAUTIC RADIO DEVELOPMENTS [SIMULTANEOUS BEACON SIGNALS AND TELEPHONY: AIRCRAFT AERIALS: PREVENTION OF COLLISION BY ULTRA-SHORT WAVES].—U.S. Bureau of Standards. (*Journ. Franklin Inst.*, Jan., 1931, Vol. 211, No. 1, pp. 113-114.)

A combined transmitter is being developed for the simultaneous broadcast of radio telephone and visual type radio range beacon signals, with the object of enabling the pilot to receive beacon service while receiving weather or other telephonic information. "A master oscillator controls simultaneously a radio telephone transmitter and a beacon transmitter. The former supplies the carrier frequency waves and the speech-modulated waves to an open antenna. The latter supplies only the radio beacon sidebands to the beacon loop antennae. Filter arrangements and automatic volume control have been worked out to facilitate the reception of these signals aboard the aircraft." Tests have been made approximately 125 miles from the transmitter which show that the feasibility of the combined service is assured.

A study is in progress of the characteristics and performance of airplane receiving antennae of various types. "A number of different antenna arrangements have been studied, both by theoretical analysis and by practical observation in the air and on the ground. For each antenna studied, the tests in the air included observation of the received voltage, the localising effect or variation of the received voltage in the immediate vicinity of the beacon tower, and the course errors as observed by circling the beacon. The antenna arrangements studied included the inclined antenna, with both forward or backward inclination (one example of the latter being the trailing wire antenna); the horizontal dipole antenna; the horizontal V antenna; the horizontal L antenna; the inclined V antenna; the symmetrical transverse T antenna; and the symmetrical longitudinal T antenna. The symmetrical longitudinal antenna with a vertical lead-in was found to have an advantageous combination of the desired operating characteristics." Symmetry of the electrical effect of the airplane

frame acting as the counterpoise is essential. "This type of antenna is free from course errors in radio range beacon reception. It is superior to the vertical pole antenna structurally, and in respect of ice formation, mechanical vibration and aerodynamic resistance."

Preliminary work has also been begun on the development of a radio system to aid in preventing collisions between airplanes. "The system involves the continuous transmission of ultra-high-frequency radio waves from each airplane. Directivity of reception or transmission, or both, will inform the pilot of the direction of danger."

THE DEVELOPMENT OF A VISUAL TYPE OF RADIO RANGE TRANSMITTER HAVING A UNIVERSAL APPLICATION TO THE AIRWAYS.—W. E. Jackson and S. L. Bailey. (*Proc. Inst. Rad. Eng.*, Dec., 1930, Vol. 18, pp. 2059–2101.)

A long paper on the polydirectional beacon for visual reception, capable of being used as a simple two- or four-course transmitter, or as a twelve-course beacon for terminal locations where there is a concentration of airways (*cf.* Diamond and Kear, 1930 Abstracts, p. 573). Considerable attention is given to the method for obtaining a three-phase r.f. supply and to the methods used to determine the phase displacements; also to the detrimental effects of cross-couplings between the loop aerials, and the elimination of these couplings. A complete schematic diagram is included.

SIGNALLING ARRANGEMENTS FOR INTERLOCKED-SIGNAL BEACONS.—(German Pat. 502562, Lorenz, pub. 14th July, 1930.)

The interlocked signals (*e.g.*, ·— and —·) are intended to fuse into a long dash on the equi-signal path, but to obtain this result special signalling methods are necessary. According to the invention, the energy is led to the two aerials by way of two circuits each containing an iron-cored choke. The signalling current decreases the magnetic bias of the one choke and simultaneously increases that of the other.

ACOUSTICS AND AUDIO-FREQUENCIES.

THE THEORY AND PERFORMANCE OF CERTAIN TYPES OF MODERN ACOUSTIC APPARATUS FOR REPRODUCING SPEECH AND MUSIC [LOUD SPEAKERS.]—N. W. McLachlan and G. A. V. Sowter. (*Phil. Mag.*, Jan., 1931, Ser. 7, Vol. 11, pp. 1–54.)

Authors' abstract:—In a former paper published in this Journal analyses were given of both coil- and reed-driven rigid disks as applied to the reproduction of sound. The object of the present contribution is to point a comparison between theory and practice, using these analyses. It is shown that both coil- and reed-driven disks, *where the whole moving system is quite rigid*, would be of little value in the reproduction of speech and music. The energy from the coil-driven disk decreases very rapidly above 1,000 cycles (although good results are obtained on its axis), whereas the energy from the reed-driven disk is centred round the resonance frequency of the combination.

The case of a reed-driven flexible disk is analysed, and the results confirmed by experiment. It fails as a reproducer owing to the prominent (low damped) natural frequencies and the wide gaps between them where the radiation is small, due to the limited number of modes of the disk in the audible register.

In practice conical and reed-driven diaphragms give better results than those to be expected from the rigid disk theory. This is due mainly in the coil case to the elasticity of the general structure, and in both coil and reed drives to the "break-up" or modes of the diaphragm. The net result is an almost continuous succession of minor resonances and a tendency to uniformity in total radiation over a definite band of frequencies.

Various aspects of the problem are treated in detail, "modes" of the combinations being investigated and practice compared with theory. The problem of linear action in diaphragms is discussed, and it is shown that for a moderate output alien frequencies are not generated by the diaphragm, but may be caused by restriction of the axial motion at low frequencies due to an inelastic restoring force. In the reed drive even at moderate intensities, the excursion must be limited, not only for preservation of a linear current-deflexion relationship, but also to avoid undue bending stress in the reed at the support. Data are given to indicate the axial amplitude required to radiate a definite amount of power. It is shown that when the power is large, low frequencies cannot, in general, be radiated at full strength.

The radial velocity of sound has been measured in aluminium and in steel disks, also near the periphery of a conical diaphragm. In the latter case it is considerably less than that of sound in air.

The reproduction of transients by a coil-driven rigid disk system is analysed, and the results compared with those obtained experimentally from coil- and reed-driven systems.

A summary of electrical, acoustical, and mechanical causes of distortion in a coil-driven reproducer is given, and the paper closes with an Appendix of Tables of various functions used in the calculation of data for design purposes.

DIFFRACTIVE REFLECTION AND SCATTERING OF ULTRASONIC WAVES. THEIR INFLUENCE ON TORSION-PENDULUM MEASUREMENTS OF SOUND INTENSITY.—R. W. Boyle and J. F. Lehmann. (*Canadian Journ. of Res.*, Dec., 1930, Vol. 3, pp. 491–509.)

In this paper the scattering of energy by a single obstacle has been investigated quantitatively. Relations between D/λ and the indicated radiation pressure on the obstacle should be applicable to other types of wave motion, but it is only in the case of ultrasonics that an experimental investigation can be carried out on a single obstacle of dimensions of the order of a wavelength.

NEW GIANT LOUD SPEAKER.—H. Neumann. (*Siemens Zeitschr.*, Oct., 1930.)

See 1930 Abstracts, p. 163. Loads up to 800 w. can be handled, and about 25 % is radiated as sound energy, giving easily intelligible speech at a distance of 500 metres.

STROBOSCOPIC OBSERVATION OF LOUD SPEAKER DIAPHRAGMS.—M. von Ardenne. (*Electronics*, Oct., 1930, p. 348.)

Summary of a paper in the Berlin *Funk*.

LOUD SPEAKER DEFLECTION MEASUREMENTS.—R. P. Glover and T. A. Hunter. (*Electronics*, Jan., 1931, pp. 474–475.)

An Ames dial gauge, graduated in ten-thousandths of an inch, is mounted over the armature drive rod: a screw adjustment to the gauge lever is provided. The gauge foot is lowered by the screw adjustment until contact with the drive rod is indicated by a sensitive grid-bias circuit and microammeter (which gets over the difficulty of contact resistance effects).

In practice it was found that the position of the drive rod could be determined to within one-quarter dial division, or within 25 millionths of an inch. The value of the apparatus in the testing of loud speakers is illustrated by specimen response curves plotted by its means. "For the first time, inspection of armature motion was possible."

OPERATING A LOUD SPEAKER WITHOUT HIGH TENSION CIRCUIT.—S. R. Khastgir and P. U. Ratnatunga. (*Nature*, 17th Jan., 1931, Vol. 127, p. 109.)

A note on a new and simple method of operating a loud speaker by means of a diode valve without using a high tension circuit. The receiver used is a single valve receiver which has a diode valve. "One side of the filament of the diode is directly connected to the earthed point of a tuned aerial circuit. The anode of the diode is inductively coupled to the tuned circuit by means of a coil with which the loud speaker is in series, and then goes back to the filament. The loud speaker operates at nearly full volume when working. Good results were obtained even with an indoor aerial. The reception took place about four miles from the receiving station, the power of which was 1.75 kw. The resistance of the loud speaker was 2,000 ohms and the current through it was only 0.1 mA. When an H.T. battery was used, the current was 6 mA. An ordinary Cossor valve was employed." It is suggested that the method might be useful in connexion with portable sets, in aeroplanes or in military manœuvres.

SAITENSCHWINGUNGEN MIT ENDLICHER AMPLITUDE (String Vibrations of Finite Amplitude).—K. Schlesinger. (*Zeitschr. f. tech. Phys.*, No. 1, Vol. 12, 1931, pp. 33–39.)

A theoretical and experimental investigation prompted by the increasing importance of the subject due to recent applications—*e.g.*, determining the temperature of filaments (Abstracts, 1930, p. 47), measuring high frequency currents (January Abstracts, p. 47), and in note generators and resonators. Analysis shows that the effect of a longitudinally responsive support is as follows:—its elasticity effects a rise of note with the square of the amplitude, while its mass effects a corresponding lowering of note; if it is in resonance with twice the natural frequency, *these two effects balance out and leave the frequency independent of amplitude*. Experimental confirmation is illustrated by oscillograms showing large vibrations with amplitudes up to 4% of the length of the string.

A DUAL-FREQUENCY AUDIO SOURCE [DYNATRON OSCILLATOR] FOR GENERAL LABORATORY USE.—G. F. Lampkin. (*Electronics*, Dec., 1930, p. 417.)

A compact instrument with a wide range of output voltages, giving one frequency near the middle of the musical range and a second near that of the voice range.

A PRECISION AUDIO FREQUENCY BRIDGE.—P. H. Dike. (*Review Sci. Instr.*, Dec., 1930, Vol. 1, pp. 744–748.)

Description of a bridge to work on a frequency range 500–3,000 cycles/sec. The system of shielding and earthing employed ensures that the detector terminals are at earth potential when the bridge is balanced, and makes the balance independent of the capacities to earth of the input leads or of the source of power, and independent also of capacities such as may be due to dead-end coils or switches. As an example of the accuracy attainable, inductances up to 100 μH. can be measured within $\pm$ 0.2 μH.; between 100 and 1,000 μH., within $\pm$ 1.0 μH.

ENUNCIATION IN LONG-DISTANCE TELEPHONY: VOCABULARIES EMPLOYED.—(*Journ. Télégraphique*, Oct., 1930, Vol. 54, pp. 266–267.)

Data from the U.S.A. show that in 500 conversations, comprising 80,000 words, only 2,200 different words were used, and that 95% of these conversations could have been carried out with 700 different words only, and 60% with only 50.

OUTPUT TRANSFORMER DESIGN.—PART II.—R. C. Hitchcock and W. O. Osbon. (*Electronics*, Dec., 1930, pp. 427–429.)

A practical paper based on the experience of the writers and on the work of Hanna, E. G. Reed and others. An approximate formula, modified from Reed's to suit the conditions, is given for the leakage reactance, and is of particular value in checking a transformer design to see if its response at high frequencies will be satisfactory. The first part of this paper (*ibid.*, Nov., 1930) discusses the general aspect of transformer design and lays the general groundwork for the actual design.

THE DESIGN OF TONE CONTROL CIRCUITS.—K. W. Jarvis. (*Electronics*, Aug., 1930, pp. 230–232 and 266.)

The writer stresses the fact that the apparent loudness of sounds is proportional to their loudness above the threshold of audibility, which varies according to the frequency; so that if a flat amplifier response curve is adhered to, a change in the absolute amplitude of the energy level produces major changes in apparent frequency response. It is this change in quality which has been one of the most elusive factors in reproducing "perfect" quality. "The elusiveness of reality demands

more than identical frequency distribution"; it requires a proper tone control which matches volume and quality. The writer describes a circuit which has proved very effective for this purpose.

SPRACHÜBERTRAGUNG UND EICHKREISE (Speech Transmission and Standard Reference Circuits [The Sfart and the Sfert]).—J. Boysen. (*Zeitschr. f. Fernmeldetech.*, 29th November, 1930, Vol. 11, pp. 161–166.)

DER FERNSPRECH-HAUPTEICHKREIS (The Telephonic Standard Reference Circuit).—W. Wolmann and E. Döring. (*Special Supplement, T.F.T.*, No. 2, Vol. 19, 17 pp.)

LA TECHNIQUE ACOUSTIQUE MODERNE ET SES APPLICATIONS (Modern Acoustical Technique and its Applications).—Ph. Le Corbeiller. (*Ann. des P.T.T.*, Nov., 1930, Vol. 19, pp. 971–989.)

SOUND-PICTURE ADVANCES—TECHNICAL IMPROVEMENTS IN 1931—NEW USES.—(*Electronics*, Jan., 1931, pp. 456–459 and 461.)

The "noiseless" recording system (Western Electric) "provides a means of broadening the volume range of recording of sound-on-film, reducing by approximately 10 decibels the ground-noise level present." An auxiliary amplifier unit is employed which varies the spacing of the light-valve ribbons from 0.3 mil to the normal 1.0 mil. A corresponding system applied to the variable-area process is that of RCA-Photophone, in which a small part of the recording amplifier output is used to provide bias for the recording galvanometer in such a way that when the output is low almost the whole width of the positive track is black; as the modulation increases, the bias changes correspondingly, until the galvanometer mirror is back to the normal position for variable-area recording. A modification of this system has been made by RKO Radio Pictures; it is expected that a similar application will be made to glow-lamp recording.

"An important development . . . is the introduction of a more efficient type of photoelectric cell in the near future which will tend to reduce the background noise of the projection system by approximately 10 decibels." No details are given.

SCANNING LOSSES IN REPRODUCTION.—N. R. Stryker. (*Journ. Soc. Motion Picture Engineers*, Nov., 1930, Vol. 15, pp. 610–622.)

"A discussion of scanning losses resulting from image-width and azimuth effects in reproduction of sound from film."

GROUND NOISE IN SOUND-ON-FILM PICTURES.—H. G. Tasker. (*Electronics*, Oct., 1930, pp. 333–335.)

ACOUSTIC AND LIGHT CHARACTERISTICS OF SOUND SCREENS.—B. Kreuzer. (*Electronics*, Dec., 1930, pp. 420–422.)

PHOTOTELEGRAPHY AND TELEVISION.

EIN NEUES FERNSEHSYSTEM (A New Television System).—A. B. Codelli. (*Fernsehen*, No. 3, Vol. 7, 1930, p. 107.)

See 1930 Abstracts, p. 576. For a summary of this paper, *see T.F.T.*, November, 1930, Vol. 19, p. 363.

STAND DER FERNBILDÜBERTRAGUNG (The Present Position of Picture Telegraphy).—H. Stahl. (*Europ. Fernspr:dienst*, Jan., 1931, pp. 47–60.)

From the German State P.O. It includes a convenient tabular comparison of seven different systems—Siemens, A. T. and T., Belin, Lorenz-Korn, Siemens Chemograph, Ranger, and Marconi-Facsimile; also extracts from the CCIT proposals as to standardisation.

TELEVISION TRANSMITTER.—T. H. Bridgewater. (*Wireless World*, 3rd September, 1930, Vol. 27, pp. 217–219.)

A description of the television transmission apparatus in the headquarters of the Baird Company in Long Acre, London.

PICTURE ANALYSIS AND TELEVISION.—J. H. Owen Harries. (*Wireless World*, 5th November, 1930, Vol. 27, pp. 527–529.)

Suggesting a method of reducing the width of sidebands necessary for television transmission by grading the analysis of the picture so that clear definition is provided only at the centre of interest, *i.e.*, the centre of the picture. *Cf.* Codelli, above; also *Wireless World*, 26th Nov., 1930, p. 614 (Barton Chapple).

VACUUM-TUBE APPLICATIONS AND RELAY CIRCUITS IN TRANS-OCEANIC PHOTO-RADIO.—R. H. Ranger. (*Electronics*, Aug., 1930, pp. 224–226.)

NEW LIGHT SOURCES: NEW SYNCHRONISING METHODS.—Heinrich - Hertz Institute. (*E.N.T.*, Dec., 1930, Vol. 7, p. 504.)

Paragraph only. The Institute has been working on the concentration of glow discharge light and on the production of light by high-frequency oscillations. It has also worked out two new synchronising methods, one depending on the pulling-into-tune effect of two local oscillators, and the other using relaxation oscillations controlled by the line-frequency of the picture.

A NEW SYSTEM OF TELEVISION.— –. Brun. (*T.S.F. pour Tous*, No. 65, 1930.)

Two co-axial scanning discs are used, one with 21 radial slots and the other with 21 slots inclined at 45 degrees to the radii, revolving at different velocities in the ratio 11 to 12. Synchronism is obtained from electric clocks, no synchronising signals being transmitted.

A METHOD OF STUDYING THE EFFECT OF TEMPERATURE ON PHOTOELECTRIC CURRENTS.—D. Ramadanoff. (*Review Scient. Instr.*, Dec., 1930, Vol. 1, pp. 768–771.)

The usual method of separating the photoelectric

current from the thermionic current which tends to mask it at high temperatures, by balancing out the latter current (1930 Abstracts, p. 221, Berger), leads to difficulties by the thermionic current varying slightly and upsetting the balance. The writer's method, involving a rotating perforated disc and a cathode-ray oscillograph, completely filters out the thermionic component, and has other advantages.

ÜBER DAS PHOTOELEKTRISCHE VERHALTEN VON SALZEN (On the Photoelectric Behaviour of Salts).—H. Erbel. (*Zeitschr. f. Phys.*, Vol. 66, No. 1/2, pp. 59–68.)

THE LONGITUDINAL DISTRIBUTION OF PHOTO-ELECTRONS.—L. Simons. (*Nature*, 17th Jan., 1931, Vol. 127, pp. 91–92.)

BILDFUNKKABEL (Cable for Picture Telegraphy).—R. Feist and H. Weinnoldt. (*T.F.T.*, Oct., 1930, Vol. 19, pp. 299–303.)

Many details of the new Nauen-Berlin-Beelitz cables. *See* also January Abstracts, p. 47.

PAPER ON KERR CELLS (Measurement of Time Intervals, etc. With bibliography).—Beams.

(*See* first abstract under "Subsidiary Apparatus.")

NEON LAMPS AND THEIR PHOTOELECTRIC SENSITIVITY.—Carrara.

(*See* last abstract under "Subsidiary Apparatus.")

COPPER: COPPER OXIDE—LEAD NITRATE PHOTO-ELECTRIC CELL (WIEN TYPE).—Fink and Alpern. (*Electronics*, Oct., 1930, p. 348.)

Short summary of an American paper.

PHOTOELECTRIC CELL WITH SECONDARY EMISSION. (French Pat. 691474, Toulon, pub. 22nd Oct., 1930.)

Covering a special gas-filled photoelectric cell designed to possess the large available energy of gas-filled cells without their defects of inertia and inconstancy. The tube possesses at one end an exciting grid close to the photosensitive cathode; at the other end, near the anode, a second grid for collecting the secondary electrons emitted by the anode; and midway between these two grids it may have two auxiliary grids for modulating the electronic current for ease in amplification. A high accelerating potential is applied between the cathode-grid and the anode. The cathode end of the tube is bent at right angles to the main tube to allow the light beam to fall normally on the cathode.

PHOTOELECTRIC CELLS FOR ULTRA-VIOLET LIGHT.—H. C. Rentschler. (*Journ. Am.I.E.E.*, Vol. 49, p. 113.)

In a paper on the writer's ultra-violet photometer (1930 Abstracts, p. 292) cells are dealt with which are particularly suitable for use in various parts of the ultra-violet spectrum.

MEASUREMENTS AND STANDARDS.

VARIABLE-MU TETRODES IN LOGARITHMIC RECORDING.—S. Ballantine. (*Electronics*, Jan., 1931, pp. 472–473 and 490.)

The "variable-mu" construction originally designed for reducing distortion and cross-talk in receivers (*see* under "Valves") enables a tetrode to be produced in which the amplification and the transconductance are both exponential functions of the control-grid bias. This is done by a suitable choice of the area and mu-factors of the elementary areas of the cathode. Such a valve lends itself admirably to the design of a logarithmic indicating device capable of operating over ranges of magnitude up to a million to one.

The writer discusses the theoretical design of such an instrument and its application to the recording of field strengths in Wireless and of frequency response curves in acoustics.

MODULATION MEASUREMENTS, INCLUDING NON-LINEAR DISTORTION.—W. Runge: M. Grützmacher. (*See* abstract under "Transmission.")

SIMPLIFIED METHOD OF MEASURING BROADCAST HARMONICS.—E. C. Miller. (*Electronics*, Dec., 1930, pp. 425–426.)

"While the determination of harmonic percentages . . . is probably best effected by the use of field strength measurements at a distance, such equipment and facilities are not always available. . . ." The writer shows how an ordinary selective wavemeter can be used for the purpose: the method is particularly convenient in determining the effectiveness of harmonic suppression schemes.

EIN EINFACHER FREQUENZMESSER HOHER GENAUIGKEIT (A Simple Frequency Meter of High Accuracy).—H. Piesch. (*Zeitschr. f. hochf. Tech.*, Dec., 1930, Vol. 36, pp. 211–217.)

A paper on the "absorption circuit" method (*cf.* Aiken, 1928 Abstracts, p. 227, and—for inductance and capacity measurements—Castellain, 1930 Abstracts, p. 224) applied to the frequency measurement of distant stations. It is investigated theoretically and shown to lend itself to frequency measurements of an accuracy equal to that of the heterodyne methods, when applied according to the procedure and with the apparatus described. The absorption circuit is calibrated with the help of a luminous quartz resonator.

The procedure is as follows:—a local oscillator produces, with the received carrier wave, an interference note which is adjusted so as to produce slow beats with a tuning fork hummer. The absorption circuit is then coupled to the local oscillator, and the de-tuning of the latter is shown by the change of frequency of these slow beats. Using these beats as an indicator, the calibrated absorption circuit is adjusted by its micrometer-vernier mechanism until the beat frequency is the same as when the absorption circuit is far out of tune. By thus making use of the very steep portion of the absorption curve, a much higher accuracy of adjustment is possible than with the

ordinary resonance curve: the beats can be adjusted to within at least one-half cycle.

A METHOD OF ACCURATE MEASUREMENT OF SHORT WAVES.—G. Leithäuser. (*E.N.T.*, Dec., 1930, Vol. 7, p. 504.)

Leithäuser's method has now been applied to short waves. It consists in superposing on the short wave a high harmonic of a locally generated fundamental, and measuring the wavelength of the fundamental when interference occurs: the fundamental is then altered until its harmonic of the next higher or lower order again interferes with the short wave. These two observations give the short wave length with great accuracy.

METHODS OF MAKING LECHER-WIRE MEASUREMENTS.—G. S. Field. (*Canadian Journ. of Res.*, Dec., 1930, Vol. 3, pp. 516–520.)

Incorrect results are obtained by moving neon glow-tubes along the wires to indicate the voltage nodes, owing to their conductive (*not* capacitive) properties. Good results are obtained by placing the neon tube at the end of the wires, where it produces a *constant* end effect, and moving shorting bridges to points where their presence does not cause the tube to stop glowing. But by far the best method is to use a thermogalvanometer across the far ends of the wires: adjusting a shorting bridge to a nodal point then gives an abrupt rise in galvanometer current, and an accuracy of 1 mm. (for 5 m. waves) is easy.

THE MUTUAL INDUCTANCE OF SHORT CONCENTRIC SOLENOIDS.—H. B. Dwight and P. W. Sayles. (*Journ. Math. Phys., Massach. Inst. Tech.*, Vol. 9, 1930, pp. 162–165.)

A series formula containing log terms is given which is very rapidly convergent for the mutual inductance of short solenoids close together, for which other series formulæ do not converge quickly enough for practical use.

A STUDY OF THE HIGH-FREQUENCY RESISTANCE OF SINGLE LAYER COILS.—A. J. Palermo and F. W. Grover. (*Proc. Inst. Rad. Eng.*, Dec., 1930, Vol. 18, pp. 2041–2058.)

Giving the experimental results of a systematic study of the r.f. resistance of single layer coils of the forms and sizes usual in circuits in the Broadcast frequency band. They show that a theoretical formula for the resistance ratio of single layer coils must involve not only the frequency, size of wire and pitch of winding, but also the number of turns and diameter of winding. Of existing formulæ, only Hickman's include all the parameters, but they are not adapted to frequencies above a few kilocycles.

This difficulty is removed by expanding them in asymptotic series. Since Hickman's expressions apply strictly only to coils very long or very short compared with their diameters, the empirical formula given is a combination of the two limiting Hickman formulæ and gives much closer agreement with the measured values of the coils under consideration, whose lengths are of the same order as their diameters.

THE MEASUREMENT OF THE DECREMENT OF PIEZO-ELECTRIC RESONATORS.—K. S. Van Dyke. (*Proc. Inst. Rad. Eng.*, Dec., 1930, Vol. 18, p. 1989.)

Summary only. Values of decrement for quartz resonators obtained to date by a c.-r. oscillograph method indicate that the values of resistance quoted four years ago, when presenting the network equivalent of the crystal resonator, should be decreased by a factor between 5 and 10. This brings them into agreement with observations by Terry on the conditions for oscillations of crystal-controlled valve circuits, and with recent measurements of decrement by Vigoureux.

SUMMARY OF PIEZO-ELECTRIC CRYSTAL CONFERENCE HELD BY U.S. NAVY DEPARTMENT, 3RD–4TH DECEMBER, 1929.—(*Proc. Inst. Rad. Eng.*, Dec., 1930, Vol. 18, pp. 2128–2135)

Including a short description of the methods of cutting quartz used at the Naval Research Laboratory, and a summary of an account of the experience and practices of the laboratory relative to the two principal "cuts" (Curie or X and 30-deg. or Y cuts).

PIEZO-ELECTRIC TERMINOLOGY.—W. G. Cady. (*Proc. Inst. Rad. Eng.*, Dec., 1930, Vol. 18, pp. 2136–2142.)

PIEZOELECTRIC CIRCUIT.—(German Pat. 494781, Radiofrequenz, Eberhardt, pub. 28th June, 1930.)

A "specially advantageous" crystal-controlled oscillator circuit in which one side of the crystal is connected to the grid of a triode, and the other side through two inductances to the anode and cathode.

THE DESIGN AND MANUFACTURE OF QUARTZ PLATES.—S. Matsumura and K. Takahashi. (*Electrotech. Lab. Circulars*, No. 72, Sept., 1930.)

In Japanese. The writers' experiences lead them to abandon plates cut perpendicularly to the geometrical axis, owing to their possessing two or three frequencies about 10 kc. apart. On the other hand, in the case of the thickness oscillations of a circular plate cut perpendicularly to the electrical axis, twin oscillations are sometimes present if the dimensional ratio d/l_x happens to be slightly greater than any whole number: plates so dimensioned must therefore be avoided.

TEMPERATURE CONTROL FOR FREQUENCY STANDARDS.—J. K. Clapp. (*Proc. Inst. Rad. Eng.*, Dec., 1930, Vol. 18, pp. 2003–2010.)

Author's summary:—A brief summary of the factors influencing the stability of temperature-control assemblies, in which control is obtained by adding heat and without the use of circulating mechanisms, is given. These factors include the degree of insulation; rate of application and method of distribution of heat; sensitivity, regularity of operation, and position of thermostat; degree of "ripple" attenuation; and the operating temperature. Examples of three types of control units regulating to within approximately $\pm$ 0.5 deg.,

$\pm$ 0.1 deg., and $\pm$ 0.01 deg. C., respectively, at 50 deg. C. are given, with heating rates and details of construction. Diagrams and photographs are included.

String Vibrations of Finite Amplitude.—Schlesinger. (*See* under "Acoustics.")

Zur Theorie der Tonfrequenzmessgeräte mit Trockengleichrichtern (The Theory of Audio-frequency Measuring Instruments incorporating Dry-Plate Rectifiers).—R. Feldtkeller and H. Kerschbaum. (*T.F.T.*, Nov., 1930, Vol. 19, pp. 333–340.)

Appareil pour le Mesure de la Résistance des Prises de Terre (Apparatus for the Measurement of the Resistance of Earths).—Bigorgne: Mocquard. (*Ann. des P.T.T.*, Oct., 1930, Vol. 19, pp. 902–905.)

A practical form of the vibrator instrument on Mocquard's principle.

SUBSIDIARY APPARATUS AND MATERIALS.

A Review of the Use of Kerr Cells for the Measurement of Time Intervals and the Production of Flashes of Light.—J. W. Beams. (*Review Sci. Instr.*, Dec., 1930, Vol. 1, pp. 780–793.)

Including an exhaustive bibliography of the Kerr effect and Kerr cell.

A New Method of Recording Electrons [Cathode Rays].—P. H. Carr. (*Review Sci. Instr.*, Dec., 1930, Vol. 1, pp. 711–743.)

Author's abstract:—"A brief review is given of the use of photographic plates for the recording of electrons. Photographic plates are rendered more sensitive to the action of electrons by the application of a small amount of certain oils; but whether oiled or not, photographic plates are insensitive to the action of electrons when they strike the plate with a speed of less than 25 equivalent volts. This work indicates that the sensitizing action of oil is largely due to cathode-luminescence of the oil, and that the failure of the photographic plate to record low speed electrons is due to the high electrical resistance of the photographic emulsion.

"Announcement is made of the discovery of the fact that metal surfaces are affected by electron bombardment in such a way that the bombarded regions react differently toward certain vapours than do the unbombarded regions. This effect has been observed even when the speed of the impinging electrons was only 12 equivalent volts. Experiments on silver and gold are presented in detail, and the practical use of the effect for electron recording demonstrated. Possible causes of the effect are also discussed.

"When the two methods for recording electrons are compared, it is found that the photographic method has the advantage of speed and ease of reproduction; while the metal method has the advantage of reliability, freedom from charging up, and insensitivity to light. Moreover, the metal method can be used for lower speed electrons than can the photographic method."

For gold, the best developer is warm mercury vapour; for silver, iodine; for zinc (an "unreliable" agent for recording, but—when good—undoubtedly the best), hydrogen chloride. Above an electron speed of 15 equivalent volts, an exposure of 5,000 micro-coulombs per sq. cm. was nearly always successful.

Nutzeffekt des Kathodenstrahloszillographen (The Efficiency of the C.-R. Oscillograph).—M. Knoll. (*Zeitschr. f. tech. Phys.*, No. 1, Vol. 12, 1931, pp. 54–62.)

An investigation of the comparative efficiencies, for a field voltage of 70 kv., of high-vacuum photography, electron window photography, fluorescent screen contact photography, and fluorescent screen camera photography.

Die Leistungsgrenze des Kathodenoszillographen (The Output Limit of the Cathode Ray Oscillograph).—W. Rogowski, E. Flegler and K. Buss. (*Arch. f. Elektrot.*, 7th Nov., 1930, Vol. 24, No. 4, pp. 563–566.)

Gland Seal with Provision for Checking, for C.-R. Oscillographs.—K. Beyerle. (*Arch. f. Elektrot.*, 23rd Aug., 1930, Vol. 24, pp. 257–258.)

Voltage Compensator.—Sola Corporation. (*Electronics*, Dec., 1930, p. 444.)

On sale at 8 dollars, this unit delivers 0.90 A. at 110 V. "within narrow limits"; input voltage 95–135 V., 60 cycles only.

La Réalisation d'une Résistance pour les Mesures en très haute Tension (The Design of a Resistance [of Negligible Reactance and Capacity to Earth] for Measurements at Very High Voltages).—P. de la Gorce. (*Comptes Rendus*, 22nd Dec., 1930, Vol. 191, pp. 1297–1299.)

Aimantation d'une Substance ferromagnétique sous l'Influence d'un Champ alternatif (Magnetisation of a Ferromagnetic Substance under the Influence of an Alternating Field).—St. Procopiu. (*Journ. de Phys. et le Rad.*, November, 1930, Vol. 11, pp. 365–372.)

A study of iron and steel under the influence of a constant magnetising field on which is superimposed longitudinal or circular a.c. (50 cycles/sec) or oscillating (10^4, 10^5 and 10^6 cycles/sec.) fields. The magnetisation first increases, reaches a maximum when the alternating or oscillating field attains the value of the coercive field of the metal, and then diminishes. This applies to frequencies up to 2.4×10^5 cycles/sec. Between this point and 10^6 cycles/sec., the magnetic properties of both iron and steel undergo a change, and the variation of magnetisation takes place with much greater difficulty at 2×10^6 cycles/sec.

Ferromagnetische Materialen bei schwachen Wechselfeldern (Ferromagnetic Materials in Weak Alternating Fields).—R. Goldschmidt. (*Zeitschr. f. tech. Phys.*, Nov., 1930, Vol. 11, pp. 452–455.)

EFFECT OF GRAIN SIZE ON THE MAGNETIC PROPERTIES OF LOW HYSTERESIS ELECTRICAL SHEETS.—V. S. Messkin and E. I. Pelz. (*Trans. Inst. Metals, Moscow,* No. 11, 1930, 39 pp. and plates.)

Russian, with German summary.

NOTE ON THE ELECTRICAL RESISTANCE OF CONTACTS BETWEEN NUTS AND BOLTS.—F. Wenner, G. W. Nusbaum, and B. C. Cruickshanks. (*Bur. of Stds. Journ. of Res.*, Sept., 1930, No. 3, Vol. 5, pp. 757–766.)

THE USE OF DISCHARGE TUBES IN ELECTRIC CIRCUITS.—R. Ruedy. (*Journ. Franklin Inst.*, Nov., 1930, Vol. 210, No. 5, pp. 625–644.)

The self-adjusting properties of the discharge tube render it a valuable adjunct in problems of automatic controlling circuits. Its disadvantages are the fairly high potentials which are necessary for its working and the series resistance which must always be included. In this paper various applications of the tube are described ; it may be used as a voltage reducer, regulator or rectifier (in particular a gas-incandescent-cathode rectifier), as a relay, as a glow tube buzzer or a gas-filled photoelectric cell. Lastly, reference is made to its use as a light source.

AN APPARATUS FOR OBTAINING HIGH SPEEDS OF ROTATION.—J. W. Beams. (*Review Scient. Instr.*, Nov. 1930, Vol. 1, pp. 667–671.)

Application of the Henriot-Huguenard air-bearing principle (1928 Abstracts, p. 694).

ÜBER PUNKTWEISE AUFNAHME QUASISTATIONÄRER VORGÄNGE (On Point-by-Point Photography of Quasi-Stationary Phenomena).—M. Büge. (*Arch. f. Elektrot.*, 28th June, 1930, Vol. 24, No. 1, pp. 44–52.)

THE TECHNIQUE OF COPPER-PYREX TUBE-SEALS.—H. W. B. Skinner and J. H. Burrow. (*Journ. Scient. Instr.*, Sept., 1930, Vol. 7, pp. 290–291.)

HOT CATHODE RECTIFIERS WITH METALLIC DISCHARGE CHAMBERS, WITH GREAT CONSTANCY OF OUTPUT.—H. Wendt. (*E.T.Z.*, 13th Nov., 1930, Vol. 51, pp. 1584–1585.)

FORTSCHRITTE AUF DEM GEBIETE DES OXYDKATHODEN-GLEICHRICHTERS (Progress in Oxide-Coated Cathode Rectifiers).—W. Germerhausen. (*Helios*, Vol. 36, 1930, pp. 1–5 and 9–10.)

A paper on the latest forms of hot-cathode rectifiers referred to in 1930 Abstracts, p. 643.

NOTE ON THE USE OF THE CYCLOGRAM FOR THE DETERMINATION OF WAVE-FORM.—Wm. Cramp. (*Journ. I.E.E.*, Dec., 1930, Vol. 69, pp. 81–82.)

THE CALCULATION OF HARMONICS IN RECTIFIED CURRENTS.—E. L. E. Wheatcroft. (*Journ. I.E.E.*, Dec., 1930, Vol. 69, pp. 100–108.)

ON THE GLOW DISCHARGE AT THE ACTIVE ELECTRODE OF AN ELECTROLYTIC RECTIFIER.—J. S. Forrest. (*Phil. Mag.*, December, 1930, Series 7, Vol. 10, No. 67, pp. 1003–1014.)

VALVE IGNIX (THE IGNIX TYPE 10 VALVE FOR FULL-WAVE RECTIFICATION).—L. La Porte. (*QST Franç.*, Dec., 1930, pp. 50–54.)

Argon-filled, with filament coated with barium oxide. The manufacture and the theory of the action are described.

NEW TRENDS IN MERCURY ARC RECTIFIER DEVELOPMENTS.—O. K. Marti. (*Journ. Am. I.E.E.*, Oct., 1930, Vol. 49, pp. 834–838.)

THE THEORY OF ELECTROLYTIC VALVE ACTION.—E. Newbery. (*Nature*, 27th Dec., 1930, Vol. 27, p. 1013.)

An insulating anodic film is built up which is impermeable to the large anions usually present but permeable to hydrogen ions. As the films are very thin and the hydrogen ions very rapid, there is no difficulty in accounting for the observed rapid changes of potential and all the known phenomena of electrolytic valve action.

DER SELENGLEICHRICHTER (The Selenium Rectifier).—F. Noack. (*Zeitschr. V.D.I.*, 10th Jan., 1931, Vol. 75, p. 48.)

PARAGUTTA, A NEW INSULATING MATERIAL FOR SUBMARINE CABLES.—A. R. Kemp. (*Journ. Franklin Inst.*, Jan., 1931, Vol. 211, No. 1, pp. 37–58.)

OSZILLOGRAPHIE VON STRÖMEN IN ISOLIERSTOFFEN (Oscillography of Currents in Insulators).—A. Gemant. (*Arch. f. Elektrot.*, 30th May, 1930, Vol. 23, No. 6, pp. 683–694.)

THE TESTING OF CONDENSER PAPER.—F. L. Roman. (*Am. Soc. for Testing Materials*, 1930, Preprint 101.)

REPORT OF COMMITTEE D-9 ON ELECTRICAL INSULATING MATERIALS.—(*Am. Soc. for Testing Materials*, 1930, Preprint 82.)

EXPERIMENTAL INVESTIGATION OF THE EFFECT OF MAGNETIC FIELDS ON THE DIELECTRIC STRENGTH OF INSULATORS.—A. Smurow. (*E.T.Z.*, 16th Oct., 1930, Vol. 51, pp. 1459–1462.)

TEILDURCHSCHLAG VON FESTEN ISOLATOREN (Partial Breakdown of Solid Insulators).—Lydia Inge and A. Walther. (*Arch. f. Elektrot.*, 27th Sept., 1930, Vol. 24, No. 3, pp. 259–284.)

THE THERMAL RESISTIVITY OF SOLID DIELECTRICS.—Report of British E.R.A. (*Journ. I.E.E.*, Oct., 1930, Vol. 68, pp. 1313–1355.)

UNTERSUCHUNGEN ÜBER DIE DIELEKTRISCHE FESTIGKEIT FESTER ISOLATOREN (Investigations on the Dielectric Strength of Solid Insulators).—K. Meyer. (*Arch. f. Elektrot.*, 23rd Aug., 1930, Vol. 24, No. 2, pp. 151–173.)

Feldverteilung und Durchschlagspannung von festen Isolatoren. I (Distribution of Field and Breakdown Voltage of Solid Insulators. I).—Lydia Inge and A. Walther (*Arch. f. Elektrot.*, 28th June, 1930, Vol. 24, No. 1, pp. 88–98.)

Untersuchungen über der Einfluss der Wärme auf den elektrischen Durchschlag fester Isolatoren (Investigations on the Influence of Heat on the Electrical Breakdown of Solid Insulators).—K. Moerder (*Arch. f. Elektrot.*, 23rd Aug., 1930, Vol. 24, No. 2, pp. 174–201.)

High Voltage Porcelain Condensers [for Carrier Telegraphy, etc.].—W. Regerbis. (*Telefunken Zeit.*, No. 54, Vol. 11, pp. 16–28.)

A Slow-Acting Vacuum Tube Relay.—D. Pollack. (*Electronics*, Oct., 1930, pp. 342–343 and 360.)

Based on the delay-time of a receiving valve filament. A suitable choice of valve type will cover a range from a tenth of a second to three minutes.

Moving Magnetised Band or Disc as Delay-Action Relay.—(French Patent 691165, S.F.R., pub. 2nd Oct., 1930.)

For summary, see *Rev. Gén. de l'Élec.*, 27th Dec., 1930, Vol. 28, p. 227D.

Cold "Soldering."—M. C. Marsh. (*Journ. Sci. Instr.*, Dec., 1930, Vol. 7, p. 399.)

Where heating is absolutely prohibited, copper or brass surfaces may be "soldered"—satisfactorily as regards electrical connection—by the use of dental copper amalgam.

Sulle Lampade a Neon (Neon Lamps [and their Photoelectric Sensitivity]).—N. Carrara. (*Nuovo Cim.*, No. 8, Vol. 7, 1930, pp. 318–325).

STATIONS, DESIGN AND OPERATION.

Les Mesures d'Intensité de Champ et leur Application pratique (Field Strength Measurements and their Practical Application).—S. Lemoine. (*L'Onde Élec.*, Dec., 1930, Vol. 9, pp. 545–552.)

Sweden is one of the largest countries in Europe, it is rather sparsely populated, and the nature of its terrain is less favourable to Wireless than that of most of the other countries. The number of wavelengths allotted to her is very limited, far too limited to allow any "waste." The Swedish administration has therefore paid particular attention to field strength measurements: their preliminary calculations, from measurements on small existing stations, of the field strength contour chart of the high power Motala station were fulfilled within 5%.

Charts are given of the Motala, Sundsvall, Hörby and Gothenburg stations. Hörby (257 m.) has a better range than Gothenburg and Sundsvall, in spite of the longer wavelengths of these (322 and 545 m.), probably owing to its being in comparatively flat and unwooded country. The writer mentions that these charts have been useful in another way—they have been distributed gratuitously to the trade, and by guiding the latter in selling their sets for different localities have overcome troubles which had occurred previously owing to over-optimistic ideas as to the ranges of the regional stations.

In urging the importance of international collaboration in such measurements, the writer makes a suggestion to overcome the difficulty in determining the effective height (especially for half-wave aerials and aerials coupled by series condensers) for use in the Austin formula. He recommends that the product Ih should in every case be calculated by field strength measurements at distances not greater than six wavelengths in the direction of least attenuation. He himself has used this plan with great success.

Field Strength Measurements of 2FC, Sydney, N.S.W.—Tippett and Baker. (*See* abstract under "Propagation of Waves.")

The Importance of Phase Control in Synchronizing [Common Wave Broadcasting].—C. W. Horn. (*Electronics*, Dec., 1930, p. 423.)

Experiments to determine the feasibility of synchronising high power stations such as WEAF, WGY, and KDKA have shown the great importance of maintaining a fixed, or only very slowly changing, phase difference.

Über eine Methode zur Schaffung guter Empfangsverhältnisse in der Grossstadt (A Method of Obtaining Good Reception Conditions in a Large City).—M. von Ardenne. (*E.N.T.*, Dec., 1930, Vol. 7, pp. 463–476.)

The full paper, an abridged version of which was dealt with in January Abstracts, p. 52 (first abstract). It includes a section on the multiple r.f. modulation of ultra-short waves referred to on the same page (second abstract), and on the demodulation of such waves at the receiving end. The very long discussion is given in full.

Broadcast Program Protection.—W. A. R. Brown. (*Rad. Engineering*, Nov., 1930, Vol. 10, pp. 27–29.)

"Control room and engineering details for setting up and maintaining satisfactory Broadcast service."

The Ljubljana Broadcasting Station.—M. Osana. (*Telefunken-Zeit.*, Dec., 1930, Vol. 11, No. 56, pp. 44–48.)

Grossrundfunksender Mühlacker (The Mühlacker High Power Broadcasting Station).—W. Meyer. (*Telefunken-Zeit.*, Dec., 1930, Vol. 11, No. 56, pp. 7–14.)

Basis Established by the Federal Radio Commission for the Division of Radio Broadcast Facilities Within the United States.—(*Proc. Inst. Rad. Eng.*, Dec., 1930, Vol. 18, pp. 2032–2040.)

UNDERGROUND CIRCUITS FOR THE TRANSMISSION OF BROADCAST PROGRAMMES.—A. C. Timmis and C. A. Beer. (*P.O. Elec. Eng. Journ.*, Jan., 1931, Vol. 23, Part 4, pp. 315–321.)

[BROADCAST] WIRELESS ON TRAINS.—(*Engineer*, 28th Nov., 1930, Vol. 150, p. 592.)

Short article on the service provided by the L.N.E.R. on their King's Cross-Leeds express.

GEWALTIGE SENDERNEUBAUTEN IN RUSSLAND (Huge New Station Construction in Russia).—(*Die Sendung*, 16th Jan., 1931, Vol. 8, pp. 42–43.)

After a reference to the Moscow RV. 49 transmissions in various European languages, and the counter-measures taken by Poland and Rumania in the way of "jamming" transmissions, the writer deals with other Russian stations audible in other countries (*e.g.*, Chabarowsk, so audible in the Dutch East Indies that receiving licences have had to be refused to the native population) and asserts that Königswusterhausen is now regularly interfered with by the Russian telegraph station RAX, London Regional and Gratz are badly distorted by a Leningrad station, Oslo (on both its long and medium waves) is interfered with by Rostow, and so on with numerous other European stations. Having drawn this picture of existing conditions the writer then expands on a recent announcement by the Central Radio Laboratory in Moscow that as part of the Five Years Plan 50 more stations will be erected; 11 with a telephony power of 100 kw., 38 with 10 kw., Moscow to be increased to 500 kw., and to radiate the same programme on a 60 kw. short wave transmitter.

AVIATION COMMUNICATION.—J. S. Richardson. (*Proc. Inst. Rad. Eng.*, Dec., 1930, Vol. 18, pp. 2143–2159.)

A paper from Canada. It deals with the different functions of radio in the field of aviation, the requirements in the design of equipment, and gives details of equipment now operating commercially. The apparatus actually illustrated has all been developed by the Bell Telephone Laboratories, though a number of other companies have other types on the market. "Although in Canada we are not governed by the requirements of the Federal Radio Commission, the developments here will proceed along similar lines to those in the United States, in order to facilitate air travel between the two countries."

RADIO TELEPHONY: A YEAR OF ACHIEVEMENT—OPENING OF SHIP AND SHORE, AUSTRALIAN AND SOUTH AMERICAN SERVICES.—H. Faulkner. (*Electrician*, 9th Jan., 1931, Vol. 106, pp. 42–44.)

LIAISON RADIOTÉLÉPHONIQUE MADRID-BUENOS AYRES (The Madrid-Buenos-Ayres Telephone Service).—E. M. Deloraine. (*Ann. des P.T.T.*, Nov., 1930, Vol. 19, pp. 921–970.)

THE QUARTZ-CONTROLLED PONTOISE TRANSMITTER. Bigorgne and Vigneron. (*See* abstract under "Transmission.")

GENERAL PHYSICAL ARTICLES.

ON THE QUESTION OF THE CONSTANCY OF THE COSMIC RAYS AND THE RELATION OF THESE RAYS TO METEOROLOGY.—Millikan. (For this and several other Cosmic Ray abstracts, *see* under "Atmospherics and Atmospheric Electricity.")

SUR UN NOUVEL ASPECT DE LA DÉCHARGE EN HAUTE FRÉQUENCE (A New Phenomenon in the Electrodeless Discharge).—M. Chenot: G. Ferrié. (*Comptes Rendus*, 5th Jan., 1931, Vol. 192, pp. 38–40.)

Mlle. Chenot's experiments on the electrodeless discharge obtained with 3.4 m. waves led to the appearance of a series of stationary waves which indicate a wave propagation along the tube at a velocity between 3 and 5 hundredths of the velocity of light.

Ferrié suggests that Mahout and Guillet's results (*ibid.*, Vol. 191, pp. 1328 and 1331) may have been due to a propagation of movements of free electrons in a metal, analogous to that here found in a discontinuous medium formed from electrified particles.

He recalls that he himself has suggested that long-delay radio echoes may be due to such propagation at greatly reduced velocities (1930 Abstracts, p. 151.)

UNTERSUCHUNG DES EINFLUSSES ADSORBIERTER GASE AUF DEN HOCHFREQUENZWIDERSTAND EINES PLATINDRAHTES (Investigation of the Influence of Adsorbed Gases on the High Frequency Resistance of a Platinum Wire). —H. Dobretsberger. (*Zeitschr. f. Phys.*, 1930, Vol. 65, No. 5–6, pp. 334–357.)

BESTIMMUNG DER ADSORBIERTEN GASHAUT AN METALLOBERFLÄCHEN DURCH WÄGUNG (Determination by Weighing of the Adsorbed Gaseous Layer on Metal Surfaces).—I. Strohhäcker. (*Zeitschr. f. Phys.*, 20th Aug., 1930, Vol. 64, No. 3–4, pp. 248–261.)

KOVARIANTE TENSORFORMEN DES OHMSCHEN UND DES JOULESCHEN GESETZES (Covariant Tensor Forms of Ohm's and Joule's Laws).—A. Byk. (*Zeitschr. f. Phys.*, 1930, Vol. 65, No. 7–8, pp. 517–540.)

ÜBER EINE NEUE FORM DER QUASI-ELEKTROMAGNETISCHEN GLEICHUNGEN DER WELLENMECHANIK (On a New Form of the Quasi-Electromagnetic Equations of Wave Mechanics).—W. Alexandrow. (*Zeitschr. f. Phys.*, 14th Aug., 1930, Vol. 64, No. 1-2, pp. 135–146.)

SUR LE CALCUL ET LA MESURE DES CHAMPS ÉLECTROMAGNÉTIQUES DANS UN UNIVERS NON EUCLIDIEN. EXPRESSION ÉLECTROMAGNÉTIQUE DES FORCES DE GRAVITATION AGISSANT SUR DES PARTICLES ÉLECTRISÉES (The Calculation and Measurement of Electromagnetic Fields in a Non-Euclidean Universe. Electro-magnetic Equation for the Gravitational Forces acting on Electrified Particles).—M. Morand. (*Ann. de Physique*, Oct., 1930, Vol. 14, pp. 191–261.)

THE ELECTROMAGNETIC FIELD OF LIGHT QUANTA.—F. J. v. Wisniewski. (*Zeitschr. f. Phys.*, 1930, Vol. 62, No. 5-6, pp. 394–400.)

ON THE THEORY OF THE BROWNIAN MOTION.—G. E. Uhlenbeck and L. S. Ornstein. (*Phys. Review*, 1st Sept., 1930, Series 2, Vol. 36, No. 5, pp. 823–841.)

I.—ON THE MODIFICATIONS IN THE FINE STRUCTURE OF A SPECTRAL RAY PRODUCED BY MOLECULAR DIFFUSION : STUDY AS A FUNCTION OF THE ANGLE OF DIFFUSION. II.—ON THE FINE STRUCTURE OF A SPECTRAL RAY AFTER MOLECULAR DIFFUSION.—M. Vacher : J. Cabannes. (*Comptes Rendus*, 8th Dec., 1930, Vol. 191, pp. 1121–1123 ; 1123–1125.)

ÉVALUATION STATISTIQUE DE L'ÉNERGIE D'INTERACTION DE COULOMB DANS UNE MOLÉCULE (Statistic Evaluation of the Coulomb Energy of Interaction in a Molecule).—L. Goldstein. (*Comptes Rendus*, 13th Oct., 1930, Vol. 191, pp. 606–608.)

DER ELEKTRISCHE DURCHSCHLAG VON LUFT IM UNHOMOGENEN FELDE (Electrical Breakdown of Air in an Inhomogeneous Field).—E. Marx. (*Arch. f. Elektrot.*, 28th June, 1930, Vol. 24, No. 1, pp. 61–70.)

THE HALL EFFECT AND THE MAGNETIC PROPERTIES OF SOME FERROMAGNETIC MATERIALS.—E. M. Pugh. (*Phys. Review*, 1st Nov., 1930, Series 2, Vol. 36, No. 9, pp. 1503–1511.)

ÜBER DIE METALLISCHE WIDERSTANDSÄNDERUNG IN STARKEN MAGNETFELDERN (On the Variation of Metallic Resistance in Strong Magnetic Fields).—N. H. Frank. (*Zeitschr. f. Phys.*, 10th Sept., 1930, Vol. 64, No. 9-10, pp. 650–656.)

ELECTRICAL RESISTANCE OF NICKEL AND PERMALLOY WIRES AS AFFECTED BY LONGITUDINAL MAGNETISATION AND TENSION.—L. W. McKeehan. (*Phys. Review*, 1st Sept., 1930, Series 2, Vol. 36, No. 5, pp. 948–977.)

GAMMA RAYS FROM POTASSIUM.—F. Behounek : W. Kolhörster. (*Sci. News-Letter*, 20th September, 1930, Vol. 18, p. 184.)

The first writer has confirmed the statement of the second that potassium chloride emits gamma rays. The intensity (which is very low) is proportional to the amount of potassium ; there are two types, one about as penetrating as the similar rays from radium, the other about twice as penetrating.

FADENFÖRMIGE, SICHTBARE ELEKTRONENSTRAHLEN (Visible Filiform Electron Beams).—E. Brüche and W. Ende. (*Zeitschr. f. Phys.*, 20th Aug., 1930, Vol. 64, No. 3/4, pp. 186–190.)

Authors' summary :—Success has been attained in the production of visible beams of slow electrons [with energies of the order of 100 v.] of which the length may exceed 1 metre while the cross-section remains small. Different cases of deviation in a magnetic field are shown and reference is made to the possibilities of scientific and technical applications of the beams.

OVER DE BAAN VAN ELECTRISCH GELADEN DEELTJES ONDER INVLOED VAN EEN ELECTROSTATISCH VELD (On the Path of Electrically Charged Particles under the Influence of an Electrostatic Field).—J. H. van der Tuuk. (*Physica*, 1930, Vol. 10, No. 7, pp. 231–233.)

WAVE MECHANICS OF DEFLECTED ELECTRONS.—C. Eckart. (*Phys. Review*, 1st Sept., 1930, Series 2, Vol. 36, No. 5, p. 1014.)

A letter referring to the discussion under a similar title by Leigh Page (*cf.* 1930 Abstracts, p. 646) of the wave mechanics of the deflection of cathode rays by homogeneous fields. The writer points out that wave mechanics and classical mechanics do agree in the formulæ by which they relate the mean radius of curvature of the cathode beam to $\frac{e}{m}$ and the field strength.

A DETERMINATION OF E/M FOR AN ELECTRON BY DIRECT MEASUREMENT OF THE VELOCITY OF CATHODE RAYS.—Charlotte T. Perry and E. L. Chaffee. (*Phys. Review*, 1st Sept., 1930, Series 2, Vol. 36, No. 5, pp. 904–918.)

DIRECT DETERMINATION OF THE VOLUME OF AN ELECTRON.—V. Posejpal. (*Comptes Rendus*, 24th Nov., 1930, Vol. 191, pp. 1000–1002.)

DISTINCTION BETWEEN CONTACT - POTENTIAL EFFECTS AND TRUE REFLECTION COEFFICIENTS FOR LOW-VELOCITY ELECTRONS.—H. E. Farnsworth and V. H. Goerke. (*Phys. Review*, Oct. 1st, 1930, Series 2, Vol. 36, No. 7, pp. 1190–1194.)

SECONDARY EMISSION FROM METALS BY IMPACT OF METASTABLE ATOMS AND POSITIVE IONS.—W. Uyterhoeven and M. C. Harrington. (*Phys. Review*, 15th Aug., 1930, Series 2, Vol. 36, No. 4, pp. 709–725.)

A description of experiments on the secondary electron emission from nickel electrodes due to bombardment of positive ions and metastable atoms in a neon discharge under conditions simulating those at the cathode in a glow discharge.

ELECTRONIC EMISSION FROM A METAL TARGET BOMBARDED WITH POSITIVE IONS.—C. L. Utterback and W. Geer. (*Phys. Review*, 15th Aug., 1930, Series 2, Vol. 36, No. 4, pp. 785–786.)

Abstract only.

THE VELOCITY DISTRIBUTION OF SECONDARY ELECTRONS FROM MOLYBDENUM.—T. Soller. (*Phys. Review*, 1st Oct., 1930, Series 2, Vol. 36, No. 7, pp. 1212–1220.)

Action of High Speed Electrons on Methane, Oxygen and Carbon Monoxide.—J. C. McLennan and J. V. S. Glass. (*Can. Journ. of Res.*, September, 1930, Vol. 3, No. 3, pp. 241–251.)

The Mobility of Ions in Pure Gases.—A. M. Tyndall and C. F. Powell. (*Proc. Roy. Soc. A*, Vol. 129, No. 809, pp. 162–180.)

Über die Ionisation von Gasen durch kurzwellige Röntgenstrahlen (On the Ionisation of Gases by Short-Wave X-Rays).—K. Schocken. (*Zeitschr. f. Phys.*, 4th Sept., 1930, Vol. 64, No. 7/8, pp. 458–464.)

Measurements are made of the proportion of photoelectrons to recoil electrons in ionisation of gases under the action of X-Rays. Above 0.350 A.U. the recoil electrons are found to form only a very small part of the total ionisation.

Elektronenaustausch langsamer Ionen II (Electron Exchange by Slowly-Moving Ions. II).—H. Kallmann and B. Rosen. (*Zeitschr. f. Phys*, 22nd Sept., 1930, Vol. 64, No. 11/12, pp. 806–816.)

Behaviour of Positive Ions in Hydrogen.—A. C. G. Mitchell. (*Journ. Franklin Inst.*, Sept., 1930, Vol. 210, No. 3, pp. 269–286.)

Absorption Coefficient of Slow Hydrogen Positive Rays in Hydrogen.—R. E. Holzer. (*Phys. Review*, 15th Aug., 1930, Series 2, Vol. 36, No. 4, p. 788.)

The Striated Discharge.—D. A. Keys and J. F. Heard. (*Nature*, 28th June, 1930, Vol. 125, pp. 971–972.)

Experiments by the writers have led to a modified form of the Wehner-Goldstein law on striation separation; experiments with hydrogen, oxygen, helium and neon indicate that "the law for the variation of striation separation with the radius of the tube is given by $S = A + C.r^n$, where A and C are arbitrary constants depending upon the nature of the gas." Further experiments are in progress.

Moving Striations in Positive Column in Rare Gases.—R. Whiddington. (*Nature*, 27th Sept., 1930, Vol. 126, pp. 470–471.)

Current, Pressure and Frequency Relationships for the Initiation and Maintenance of the Electrodeless Glow Discharge.—M. L. Braun. (*Phys. Review*, Oct. 1, 1930, Series 2, Vol. 36, No. 7, pp. 1195–1203.)

The Propagation of Luminosity in Discharge Tubes.—J. W. Beams. (*Phys. Review*, 1st Sept., 1930, Series 2, Vol. 36, No. 5, pp. 997–1001.)

Measurement of Space-Potential in High Frequency Discharge.—D. Banerji and R. Ganguli. (*Nature*, 30th Aug., 1930, Vol. 126, pp. 309–310.)

The authors have used an extra bobbin-shaped internal electrode to complete the circuit through the "exploring electrode." This internal electrode is kept outside the region of the main discharge. The nature of the volt-ampère characteristics obtained is similar to those obtained in d.c. discharges. The concentration and the average velocity of the electrons in different parts of the discharge may be measured by this extension of Langmuir's method.

The Problem of the Mechanism of Spark Discharge.—L. B. Loeb. (*Journ. Franklin Inst.*, July, 1930, Vol. 210, No. 1, pp. 15–30.)

The Mechanism of Spark Discharges.—J. Slepian. (*Journ. Franklin Inst.*, Oct., 1930, Vol. 210, No. 4, pp. 473–475.)

MISCELLANEOUS.

On the Intensity of Polarisation or the Dielectric Displacement of a Permanent Electret: Effects of Electric Force on a Permanent Electret.—M. Eguchi. (*Proc. Phys.-Math. Soc., Japan*, Series III, Vol. 3, pp. 2–4 and 110–116.)

The effect is studied of an electric force on an electret obtained by solidifying a dielectric in a strong electric field. A slight change in the surface charge is found, but this is only temporary and the electret perfectly recovers its original polarisation. The free charge of the permanently electrified dielectric is measured by a simple electroscopic method which is described in the first paper.

For the use of the electret in a condenser microphone, in place of a polarising potential, *see* Nishikawa and Nukiyama, 1929 Abstracts, p. 217.

Outline Notes on Telephone Transmission Theory.—W. T. Palmer. (*P.O. Elec. Eng. Journ.*, Oct., 1930 and Jan., 1931, Vol. 23, Parts 3 and 4, pp. 227–233 and 309–314.)

Advances in Transoceanic Cable Technique.—H. Mason. (*Proc. Inst. Rad. Eng.*, Dec., 1930, Vol. 18, pp. 2176–2191.)

Über die Lösung von Schwingungsaufgaben mittels symbolischer Differentialrechnung (On the Solution of Oscillation Problems by means of Symbolic Differentiation).—W. Gauster. (*Arch. f. Elektrot.*, 27th Sept., 1930, Vol. 24, No. 3, pp. 360–382.)

Early Developments in A.C. Circuit Theory. Some Notes on the Application of Complex Methods to the Solution of A.C. Circuit Problems.—J. Windred. (*Phil. Mag.*, Nov., 1930, Series 7, Vol. 10, No. 66, pp. 905–916.)

Die Formel von Heaviside, ihre strenge Herleitung, kritische Wertung und Verallgemeinerung (The Heaviside Formula, its Strict Derivation, Critical Appreciation, and Generalisation).—H. Schulz. (*T.F.T.*, Aug., 1930, Vol. 19, pp. 231–243.)

On the Summability of Fourier Series. Third Note.—E. Hille and J. D. Tamarkin. (*Proc. Nat. Ac. Sci.*, Sept., 1930, Vol. 16, pp. 594–598.)

ANWENDUNG DER METHODE DER UNENDLICHEN DETERMINANTEN ZUR BERECHNUNG DER EIGENWERTE IM FALLE DES STARKEFFEKTS (Application of the Method of Infinite Determinants to the Calculation of the Eigenvalues in the Stark Effect).—K. Basu. (*Zeitschr. f. Phys.*, 10th Sept., 1930, Vol. 64, No. 9-10, pp. 708–713.)

FITTING OBSERVATIONS TO A CURVE.—N. Campbell. (*Phil. Mag.*, Nov., 1930, Series 7, Vol. 10, No. 66, pp. 745–758.)

THE THEORY OF PROBABILITY: SOME COMMENTS ON LAPLACE'S THÉORIE ANALYTIQUE.—E. C. Molina. (*Bull. Am. Math. Soc.*, June, 1930, Vol. 36, pp. 369–392; *Bell Tel. Reprint*, B. 480, June, 1930.)

ABAQUE POUR LE CALCUL DES FONCTIONS CIRCULAIRES ET HYPERBOLIQUES DE VARIABLES COMPLEXES (Abac for the Calculation of Circular and Hyperbolic Functions with Complex Variables).—L. Abélès. (*Rev. Gén. de l'Élec.*, 4th Oct., 1930, Vol. 28, pp. 515–526.)

CONTRIBUTION TO THE STUDY OF THE INFLUENCE OF POWER LINES ON TELEPHONIC LINES, AND MEASURES TO REDUCE IT.—Klewe, Rachel, Clausing, Geise, Zastrow and Schulze. (*Report No.* 35 to the 1930 World Power Conference, Berlin; 42 pp., in German.)

THE ELECTRIC FIELD PRODUCED BY A LINE CARRYING ALTERNATING CURRENT, IN THE PRESENCE OF THE GROUND.—J. B. Pomey: J. R. Carson. (*Rev. Gén. de l'Élec.*, 20th Dec., 1930, Vol. 28, pp. 985–989.)

A paper based on Carson's note to the C.C.I. in 1926.

DIE SCHWACHSTROMBEEINFLUSSUNG DURCH PLÖTZLICH GESCHALTETE ERDSTROMFELDER (Interference with Communication Lines by the Sudden Switching of Earth Current Fields).—F. Ollendorff. (*E.N.T.*, Oct., 1930, Vol. 7, pp. 393–407.)

The integral representation of the switching field and the calculation of certain integrals: the structure of the surface field: the penetration of the field to lower levels: development of a formula for the interference effect on a communication line: numerical example.

INTERFERENCE TO NEIGHBOURING COMMUNICATION LINES DUE TO DOUBLE EARTHING CURRENT [OF THREE-PHASE POWER LINES].—H. Geise and W. Plathner. (*E.T.Z.*, 25th Sept., 1930, Vol. 51, pp. 1360–1362.)

VARIATION DE LA RÉSISTANCE DES PRISES DE TERRE TRAVERSÉES EN PERMANENCE PAR UN COURANT ALTERNATIF (Variation of the Resistance of Earths traversed continually by A.C.).—G. Viel. (*Rev. Gén. de l'Élec.*, 18th Oct., 1930, Vol. 28, pp. 611–612.)

Tests over five years show that properly made earths, traversed by a current of density less than 25 A./m², retain their conductivity practically unchanged.

AN INVESTIGATION OF EARTHING RESISTANCES: DISCUSSION.—P. J. Higgs: P. D. Morgan and H. G. Taylor: G. F. Tagg. (*Journ. I.E.E.*, Oct., 1930, Vol. 68, pp. 1363–1367.)

See 1930 Abstracts, p. 525, for abstract of the original paper.

BIOLOGICAL EFFECTS OF FIELDS OSCILLATING AT ULTRA-HIGH FREQUENCIES.—S. Jellinek. (*Comptes Rendus*, 24th Nov., 1930, Vol. 191, pp. 1030–1032.)

Researches on repeated and carefully dosed exposure to ultra-high frequency fields ($\lambda = 3$ m.) of newly-born mice and of parrots' eggs. Unlike the results of Esau and Schliephake, the effects here produced were beneficial. The writer attributes the contrast to his avoidance of heating effects and to correct dosage.

HOCHFREQUENZLEITFÄHIGKEIT STARKER ELEKTROLYTE IN WÄSSERIGEN ZUCKERLÖSUNGEN (High-Frequency Conductivity of Strong Electrolytes in Aqueous Sugar Solutions).—S. Mizushima and H. Sack. (*Physik. Zeitschr.*, 15th Sept., 1930, Vol. 31, No. 18, pp. 881–815.)

ON THE MECHANISM OF VERY ABSORBABLE RADIATION EMITTED BY COMPRESSED CRYSTALLINE SUBSTANCES UNDER HIGH POTENTIALS.—I. A. Balinkin. (*Phys. Review*, No. 11, Vol. 35, 1930, p. 1443.)

Further developments along the lines of Reboul's work (1930 Abstracts, p. 413). The action of these "radiating cells" is attributed to the recombination of ions in the gaps in the compressed crystalline substance.

ELEKTRISCHE ENTLADUNGEN IN KRISTALLEN (Electrical Discharges in Crystals).—Lydia Inge and A. Walther. (*Zeitschr. f. Phys.*, 22nd Sept., 1930, Vol. 64, No. 11/12, pp. 830-842.)

DISCHARGES IN NEON.—P. Johnson. (*Phil. Mag.*, Nov., 1930, Series 7, Vol. 10, No. 66, pp. 921–931.)

THEORETICAL AND EXPERIMENTAL INVESTIGATION OF A METHOD OF REGISTERING SMALL CAPACITY CHANGES, FOR THE CONTINUOUS RECORDING OF PROCESSES IN PROGRESS [ULTRA-MICROMETER].—A. Schulze and G. Zickner. (*Arch. f. Elektrot.*, No. 1, Vol. 24, 1930, p. 111.)

SELBSTTÄTIGES AUFZEICHNEN VON ARBEITSVORGÄNGEN (The Automatic Recording of Workshop Processes). — A. Schulze and G. Zickner. (*Zeitschr. V.D.I.*, 27th Sept., 1930, Vol. 74, pp. 1359–1362.)

Description of a capacity-change equipment evolved by the German State Research Establishment.

MEASUREMENT OF PRESSURES, ESPECIALLY IN LIQUIDS, BY THE FREQUENCY-DEPENDENCE OF THE DIELECTRIC CONSTANTS.—F. Trendelenburg. (*Zeitschr. f. tech. Phys.*, Nov., 1930, Vol. 11, pp. 465–474.)

DETERMINING COMPARATIVE AREAS OF IRREGULARLY-SHAPED MICROSCOPIC OBJECTS BY THE USE OF A PHOTOELECTRIC CELL.—A. Savage and M. C. Jamieson. (*Canadian Journ. of Res.*, Oct., 1930, Vol. 3, No. 4, pp. 322–326.)

E.g., blood corpuscles: by staining them with fuchsine and projecting their magnified images on to a photoelectric cell insensitive to red light.

CAN A WIRELESS RECEIVER RECORD AND PRESERVE TRANSMISSIONS AT FIXED HOURS? [TELEGRAPHONE-RECEIVER COMBINATION].—W. Holz. (*E.T.Z.*, 2nd Oct., 1930, Vol. 51, p. 1402.)

ÜBER DIE ENERGIEUMWANDLUNG WÄRME—ELEKTRIZITÄT (The Direct Conversion of Heat into Electrical Energy).—O. Gunolt. (*E.T.Z.*, 25th Sept., 1930, Vol. 51, pp. 1363–1366.)

Thermoelectric processes in electronic conductors: in ionic conductors: thermomagnetic processes: thermodielectric processes.

ENERGY SUPPLY IN THE ARCTIC REGIONS.—H. Barjot. (*World Power*, Oct., 1930, Vol. 14, pp. 305–306.)

The economic aspect of the scheme referred to in 1929 Abstracts, pp. 228 and 650. An equipment has been installed in Siberia.

THE USE OF THE SEA'S THERMAL ENERGY.—G. Claude. (*Comptes Rendus*, 10th Nov., 1930, Vol. 191, pp. 810–813.)

First results with the Cuban plant. For a pessimistic leading article, and a reply by Claude himself, see *Engineer*, 24th Oct. and 21st Nov., 1930.

INSTRUMENT FOR DETECTING BURIED METALLIC BODIES.—T. Theodorsen. (*Journ. Franklin Inst.*, Sept., 1930, Vol. 210, pp. 311–326.)

A SENSITIVE INDUCTION BALANCE FOR THE PURPOSE OF DETECTING UNEXPLODED BOMBS.—T. Theodorsen. (*Proc. Nat. Ac. Sci.*, Nov., 1930, Vol. 16, pp. 685–693.)

THE DIVINING-ROD PROBLEM.— –. Buth. (*E.T.Z.*, 4th Dec., 1930, Vol. 51, p. 1691.)

A long letter replying to various correspondents who wrote regarding the article dealt with in 1930 Abstracts, p. 587.

SCIENCE AND BROADCASTING.—E. J. Holmyard. (*Nature*, 1st Nov., 1930, Vol. 126, pp. 673–675.)

A discussion of the programmes arranged by the British Broadcasting Corporation with special reference to the scientific talks. Suggestions are made for consolidation of the advantages obtained by such talks by arrangement of group discussions in adult education societies, etc., and for extension of the programme of broadcast talks in connection with school work, especially in scientific subjects.

EDUCATION BY RADIO: REPORT OF U.S. ADVISORY COMMITTEE.—(*Rad. Engineering*, Nov., 1930, Vol. 10, pp. 42, 44 and 46.)

THE NATIONAL PHYSICAL LABORATORY. REPORT FOR THE YEAR 1929.—(*Journ. Scient. Instr.*, Oct., 1930, Vol. 7, pp. 330–335.)

A summary.

7TH ASSEMBLY OF THE INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC), 1930: RADIO COMMUNICATIONS.—Internat. Electrot. Committee. (*E.T.Z.*, 9th Oct., 1930, Vol. 51, pp. 1415–1416.)

I.E.E. WIRELESS SECTION: CHAIRMAN'S ADDRESS.—C. E. Rickard. (*Journ. I.E.E.*, Dec., 1930, Vol. 69, pp. 11–24: *E.W. & W.E.*, Dec., 1930, Vol. 7, p. 676.)

OLYMPIA, 1930 [RADIO EXHIBITION]: A GENERAL IMPRESSION—AND SOME DETAILS.—(*E.W. & W.E.*, Nov., 1930, Vol. 7, pp. 604–608.)

THE SEVENTH INTERNATIONAL RADIO EXHIBITION, PARIS, 1930.—(*L'Onde Élec.*, Nov., 1930, Vol. 9, pp. 527–541.)

A critical survey by a group of visitors.

AIRCRAFT RADIO RESEARCH—U.S. BUREAU OF STANDARDS.—(*Journ. Franklin Inst.*, July and August, 1930, Vol. 210, No. 2, pp. 113–114 and 246–249.)

See 1930 Abstracts, p. 633 (three abstracts).

AERONAUTIC RADIO RESEARCH.—NOTES FROM THE U.S. BUREAU OF STANDARDS.—(*Journ. Franklin Inst.*, Sept., 1930, Vol. 210, No. 3, pp. 389–390.)

See 1930 Abstracts, p. 633, two abstracts on the runway localising beacon.

URSI COSMIC DATA BROADCASTS.—(*Proc. Inst. Rad. Eng.*, Sept., 1930, Vol. 18, pp. 1469–1475.)

RADIO TECHNIQUE AT THE VIENNA AUTUMN FAIR.—E. Mittelmann. (*Elektrot. u. Masch: bau*, 2nd Nov., 1930, Vol. 48, pp. 998–999.)

THE RADIO LABORATORY OF THE ELECTROTECHNICAL INSTITUTE OF THE TECHNICAL HIGH SCHOOL, VIENNA.—M. Reithoffer. (*Elektrot. u. Masch: bau*, 26th Oct., 1930, Vol. 48, pp. 962–967.)

PIEZOELECTRIC MEASUREMENT OF RAPID PRESSURE CHANGES.—Oerlikon Company. (*Génie Civil*, 3rd Jan., 1931, Vol. 98, pp. 20–21.)

DETECTING FLAWS AND VIBRATIONS IN FERROMAGNETIC ARTICLES.—J. Peltier. (*Comptes Rendus*, 29th Dec., 1930, Vol. 191, pp. 1443–1444.)

Further development of the work dealt with in 1930 Abstracts, p. 527.

PIEZOELECTRIC ACCELEROMETER AND ITS USE IN MEASURING THE VELOCITY OF ELASTIC WAVES [EARTH TREMORS].—Y. Katô and S. Nakamura. (*Proc. Imp. Acad. Tokyo*, July, 1930, Vol. 6, pp. 272–274.)

Some Recent Patents.

The following abstracts are prepared, with the permission of the Controller of H.M. Stationery Office, from Specifications obtainable at the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1/- each.

AUTOMATIC VOLUME-CONTROL.

Convention date (U.S.A.), 1st September, 1928. No. 318235.

The Figure shows a mains-driven two-stage amplifier for use with a gramophone pick-up P. Rectified current from the unit U is fed through tappings T, T_1 on a shunt resistance R to the filament of the first amplifier V, whilst the filament of the second or power stage V_1 is fed with alternating-current taken directly from a secondary winding S. The arrangement is such that if the power stage V_1 is overloaded, the increase in anode current will produce a corresponding drop in voltage across the parallel resistance R. This, in turn, reduces the filament voltage applied from the tappings T, T_1, to the preceding valve V, and thereby automatically lessens the input to the overloaded valve.

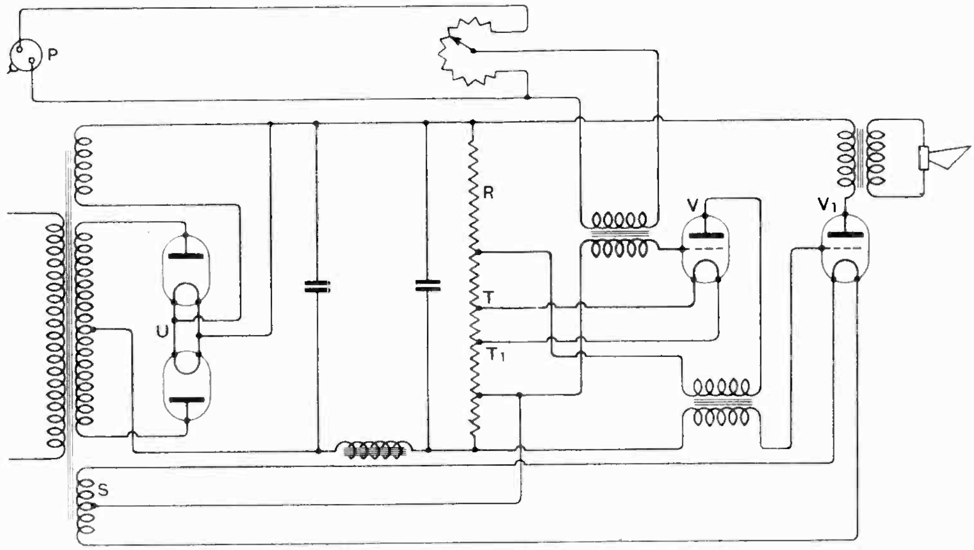
Patent issued to Victor Talking Machine Co.

SECRET DUPLEX SYSTEMS.

Convention date (Germany), 3rd July, 1928. No. 314869.

Each of two intercommunicating stations transmits a constant wave of different frequency, reception being effected on the resulting beat note. In order to ensure secrecy, the frequency used by each station is varied from time to time, but in such a manner as to maintain the beat note constant. This is effected by using piezo-electric master-oscillators at each station, and selectively changing one crystal for another of a different frequency in accordance with a prearranged time-schedule.

Patent issued to C. Lorenz Akt.



No. 318235.

LIGHT-SENSITIVE CELLS.

Convention date (U.S.A.), 16th March, 1929, No. 334409.

The cell consists of a cuprous-oxide electrode arranged in contact with an electrolyte capable of releasing nascent oxygen in such manner as to oxidise any hydrogen produced by electrolysis. This prevents the reduction of the cuprous oxide surface, and maintains the photo-sensitive response at a high level. The electrolyte used is hydrogen peroxide. A copper anode, coated with crystallised cuprous oxide, is mounted inside a glass bulb filled with the liquid electrolyte, together with a zinc cathode and an electrode of carbon or selenium to reduce polarisation.

Patent issued to Arcturus Radio Tube Co.

PORTABLE SETS.

Application date, 10th February, 1930. No. 332324.

The loud-speaker attachment to a portable set is hinged and folds down like a lid to the set. The frame aerial is similarly hinged and, when not in use, folds down over the speaker, to complete the lid. Both the speaker and aerial casings are pivoted on a fold-over flange, so that once the aerial has been orientated for optimum directional reception, the speaker can be independently turned on its pivots so as to ensure that the diaphragm faces the listeners.

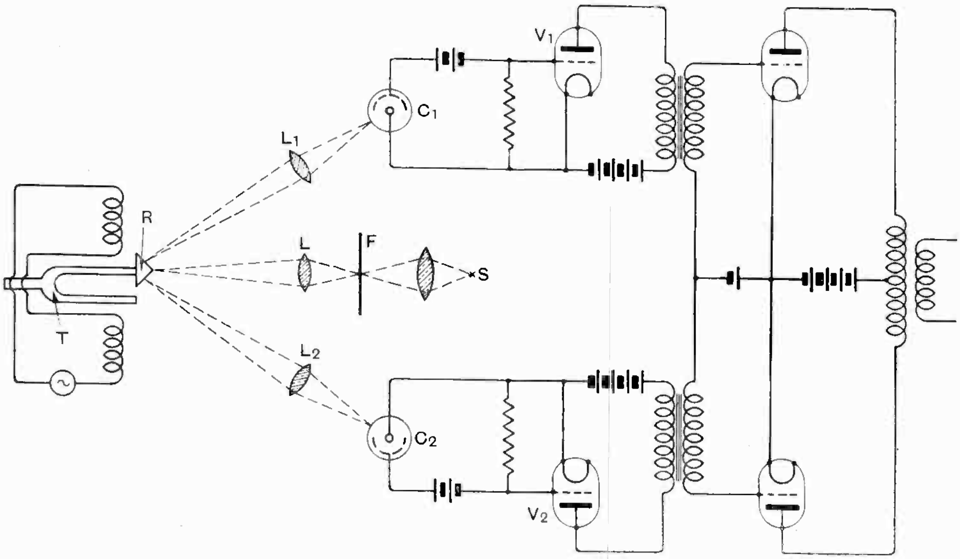
Patent issued to A. E. Telford and J. Cox.

PICTURE TRANSMISSION.

Convention date (U.S.A.), 31st October, 1928. No. 333819.

Instead of using an obturator disc to "chop" the light before it reaches the photo-electric cell, a wedge-shaped reflector R, sustained in rapid vibration by an electrically-driven tuning fork T, is arranged at the focal point of a lens system L, so that the light from a photographic film F or picture negative is broken up and distributed in rapid succession through lenses L_1 and L_2 on to corresponding photo-electric cells C_1, C_2 connected in series with valve amplifiers V_1, V_2. In this way a larger proportion of the total available light from the source S is thrown on to the cells C_1, C_2 than is possible when an obturator disc is used, owing to the rays shut off by the opaque portions of the disc.

Patent issued to Marconi's Wireless Telegraph Co., Ltd.



No. 333819.

HIGH-EMISSION CATHODES.

Convention date (Germany), 28th February, 1928. No. 306960.

The filament is coated with a layer of metallic barium, etc., by chemical action during the process of valve manufacture. A tablet of powdered barium oxide and silicon or ferro-silicon is fixed inside the anode. The valve is then connected to the pump, and after being highly evacuated is heated by high-frequency current. Metallic barium and silicon oxide are formed as a result of the reaction. The former is dispersed and precipitates on the surface of the filament in the form of metal vapour, the silicon remaining *in situ*.

Patent issued to B. Loewe.

SCREENED-GRID VALVES.

Convention date (Germany), 20th July, 1928. No. 315875.

In a screened-grid valve the "gettering" deposit is limited to the lower inside surface of the bulb by "flashing" it from behind an obstruction which screens the upper parts of the glass. A sheet-metal screening-cap is then fitted over the outside surface of the clear glass, and is provided with a terminal for connection to the filament or to earth.

Patent issued to Telefunken Gesell. für Drahtlose Telegraphie, m.b.h.

PHOTO-ELECTRIC CELLS.

Application date, 14th February, 1929. No. 333548.

In order to produce a reaction to light impulses, analogous to a "trigger" effect, use is made of the known fact that increased activity is exhibited by a photo-sensitive body when it is being subjected to electronic or cathode-ray bombardment. According to the invention the cathode of the cell is continuously bombarded by an electron stream. The sensitive cathode is supported by or deposited on a transparent insulator such as glass. The anode is of wire gauze, or may be a grid of wires in close proximity to the cathode. External to the anode, and farther away from the cathode, is a heated filament providing the electron stream. At the face of the glass plate opposite that on which the sensitive cathode is deposited a transparent sub-cathode is arranged through which the applied light passes first, so that it emerges from the sensitive cathode surface, instead of falling directly on it. This is known to increase the photo-electric emission. The heated filament is of the dull-emitter type to prevent any photo-electric action on the cathode.

Patent issued to G. W. Walton.

WIRELESS FOR AERIAL NAVIGATION.

Convention date (U.S.A.), 23rd June, 1928. No. 314310.

From a central point on an aerodrome landing-field a hollow cone of electromagnetic energy is directed upwards. The diverging cone comprises an outer zone carrying a characteristic signal, and a central space which either carries no signal energy or else contains energy having a different characteristic note. The hollow beam is radiated by a hertzian oscillator lying in the axis of a parabolic reflector. To fill the inner space with signals of a different characteristic the hertzian oscillator is combined with a ring oscillator lying in a plane at right-angles to the first. The aviator first hears the characteristic signal of the outer zone to warn him of the vicinity of the landing field. Having passed through this zone he enters the central cone and is safe in landing so long as he keeps inside it.

Patent issued to Kolster-Brandes, Ltd.

MAINS-FED VALVES.

Application date, 9th May, 1929. No. 332667.

In order to provide a convenient electrical "centre" at the cathode, to which the negative end of the anode circuit may be connected (in order to minimise hum when the cathode is heated directly from A.C. mains), a coil of thin wire is wound over, and in reverse direction to the secondary of the supply transformer. The coil is so dimensioned that its free end has the same potential as the centre, or any other desired point along the filament. In the case of an indirectly-heated valve the cathode is connected to the free end of the additional coil.

Patent issued to S. G. S. Dicker.

Convention date (Germany), 19th March, 1928. No. 308217.

Relates to indirectly-heated cathodes of the type in which the heating-filament is first surrounded by an insulating body and is then coated with an electron-emitting substance. According to the invention, the heating-filament is first immersed in a mass of barium oxide having a small content of silicon and is heated to about 300°C. When the filament is subsequently heated above 1,200° C., the barium evaporates and the residual layer forms a semi-conducting layer. Upon this is burnt a metallic coating, *e.g.*, of gold or silver in an organic solution ; or the covered filament is heated in nickel carbonyl vapour. Finally, a highly-emissive substance, such as barium, is precipitated on the metallic coating.

Patent issued to B. Loewe.

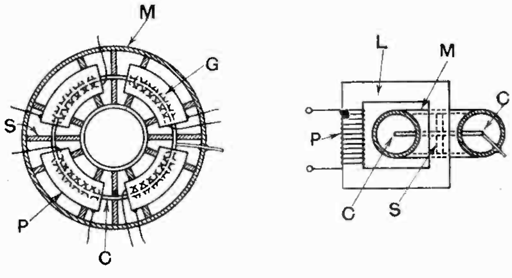
Application date, 24th June, 1929. No. 333011.

Relates to indirectly-heated cathodes of the type in which a heating-element is surrounded by a sleeve of insulating material, on the outer surface of which is deposited a high-emission coating of metal forming the cathode proper. The object of the invention is to avoid erosion of the heating-element by gases liberated by the heat from the adjacent insulating compound. This is attained by depositing, between the heating-element and the insulating sleeve, a protective coating of chromium, thorium, zirconium, or other element capable of forming compounds with, and holding indefinitely, any liberated gases deleterious to the heating-element. Preferably, the chromium or other coating is applied to the filament wire mixed with a binder, such as cellulose in amyl acetate.

Patent issued to A. S. Cachemaille.

Convention date (U.S.A.), 28th September, 1928. No. 320022.

The cathode is formed as the short-circuited secondary of a transformer, and is heated by induction from a primary winding. The object is to secure a cathode having a substantially equipotential surface, free from hum. Figure (*a*) shows a multi-stage arrangement grouped around a common cathode C mounted between spacers S and co-acting with grids G and plates P. Figure (*b*) shows the heating-arrangement separately.



(a) (b)

No. 320022.

The circular cathode C is enclosed in an exhausted toroid chamber M of glass, through which passes one limb of a magnetic core L energised by a primary winding P fed from the mains.

Patent issued to Marconi's Wireless Telegraph Co., Ltd.

Convention date (U.S.A.), 16th May, 1928. No. 311768.

In the ordinary type of indirectly heated valve the cathode maintains the same potential throughout, there being no voltage drop along its length. According to the present invention, a potential difference is deliberately introduced by thermo-electric action. The cylindrical cathode surrounding the heating-element is made in two parts, an upper cylinder of nickel and a lower one of chrome-iron alloy. Under the action of heat, a thermo-electric E.M.F. is set up between the two metals, and is utilised to impose a biasing potential on the grid. Alternatively the cathode is made in two sections of the same metal, *e.g.*, tungsten or nickel, separated by a central band of copper.

Patent issued to Arcturus Radio Tube Co.

MAINS-ELIMINATORS.

Application date, 23rd September, 1929. No. 335733.

In a smoothing-unit for D.C. mains, one of the mains is normally earthed, so that it is desirable to insert a smoothing-condenser between the other main and earth to remove the residual ripple. It is often difficult to determine which of the two mains, positive or negative, is in fact earthed at the generating station. According to the invention, the smoothing-unit is provided with a condenser, one terminal of which is permanently earthed, whilst the other terminal is provided with a change-over switch by means of which it can be connected to either of the supply mains at will.

Patent issued to S. G. S. Dicker.

DIRECTION-FINDING EQUIPMENT.

Convention date (Germany), 6th August, 1928. No. 316939.

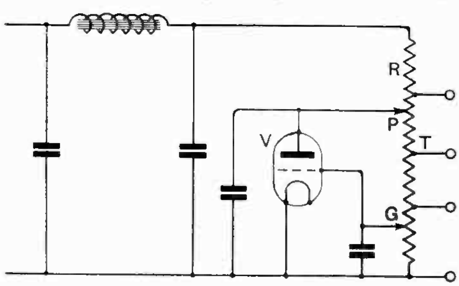
A correction for quadrantal error is made to the apparent direction of the incoming wave front, as determined by a frame aerial, by means of a shaped cam, which is arranged on a fixed bearing-disc and displaces the indicator automatically as the bearing wheel is rotated, so as to give the corrected reading by mere inspection. The correct outline of the cam is found experimentally.

Patent issued to Telefunken Gesell. für Drahtlose Telegraphie m.b.h.

REGULATING MAINS-VOLTAGE.

Application date, 27th July, 1929. No. 334028.

As an additional means of maintaining a steady voltage, particularly at the tapping point supplying, say, the plate voltage of a detector valve, part of the potentiometer resistance R of a mains-supply unit is shunted by a regulating valve V. The plate



No. 334028.

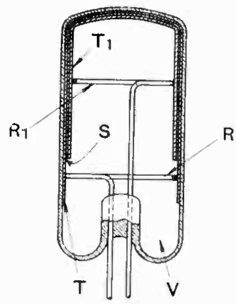
of the regulating valve is connected to a point P along the resistance R having a higher voltage than the tapping T feeding the detector valve, the grid-tapping G being taken to a point of lower potential. The adjustment is such that any fluctuation in the mains supply automatically alters the plate-filament impedance of the valve V, causing it to act as a variable shunt which stabilises the potential of all points of the resistance R below the tapping P.

Patent issued to H. Branton, H. G. Bawtree-Williams, E. A. Bitton, and H. Austin-Storry, Ltd.

SELENIUM CELLS.

Convention date (U.S.A.), 6th November, 1928. No. 333116.

A thin film of selenium is arranged so that the incident light not only falls on its surface but also passes through the thickness of the selenium, thus increasing the photo-sensitive effect. A layer T of gold so thin as to be transparent to light is first deposited on the inner surface of an evacuated bulb V. A thin film S of selenium is next sputtered on to the gold electrode. Finally, a second electrode T_1 of silver is deposited on the selenium. The silver acts to reflect any light that passes through back into the selenium. Contact with the two electrodes is made through spring wires R, R_1.



No. 333116.

Patent issued to Westinghouse Electric & Manufacturing Co.

Application date, 11th May, 1929. No. 333293.

To prevent "fatigue" the selenium is deposited on the outer surface of wire from which a part of the insulation has been removed. The wire is wound spirally around a cylindrical core, which is slowly rotated so that different portions of the selenium are intermittently exposed to the incident light.

Patent issued to W. Prior and C. Crisp.

BROADCASTING SYSTEMS.

Application date, 31st May, 1929. No. 312696.

A number of harmonic frequencies are derived from a single master source of radio frequency, and each is individually modulated. Alternate sets of side-band frequencies are then suppressed by band filters, and the resulting single side-band signals are fed through separate speech channels to corresponding aerials for simultaneous radiation. The object is to increase the permissible number of transmitters operating inside a given wavelength band without mutual interference.

Patent issued to Kolster-Brandes, Ltd.